

Ministry of Science and The Arts

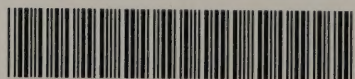
Science in Israel 1994 | 5

Practical Guide

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Ministry of Science and The Arts

Science in **Israel** **1994 | 5**

Practical guide

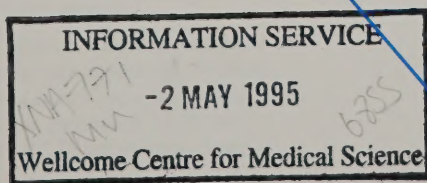


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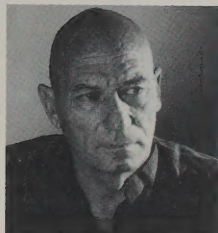
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Modern economies depend on technology, and technologies depend on research. This is particularly true for small, technically advanced countries such as

Israel, which must run twice as fast just to remain competitive. To meet this challenge, Israel devotes a full 2.3% of its entire Gross Domestic Product (GDP) to civilian R&D. This places her just behind Sweden (2.7%) and just above the USA (2.1%). Such investments support the exceptionally high percentage of scientists and engineers in Israel's workforce, 130 per 10,000 workers (compared to 77 in the USA). Their scientific productivity gives Israel the world's highest number of scientific papers per capita, 109 per 10,000 population.

In the absence of large government research institutes, most basic research in Israel is done in academia. Such research strives for scientific excellence and knowledge, not short-term profit. History shows this to be a sound long-term strategy, for our century's most important research applications were largely unanticipated. Such was the case with molecular biology (genetic engineering), semiconductor physics (microelectronics), computer science and atomic physics; and it will, no doubt, characterize the technological revolutions of the next century as well.

Still, it would be naive to underestimate the economic importance of developing and exploiting new research-based technologies. Israel's high-tech industries now account for 54% of all her industrial exports, excluding diamonds. In 1993 Israel sold \$4.5 billion worth of electronic products (broadly defined) and over \$250 million of biotechnology-based products.

How can Israel develop a close partnership between academia, government and industry to speed the application of new discoveries without diluting the seriousness of its basic scientific endeavors? In our opinion, Israel is

Foreword

best served by combining unfettered academic research with an extra-academic governmental body that promotes research directed towards applications of national importance. This first key step in the journey from laboratory is a prime responsibility of the Ministry of Science and the Arts (MOSA).

MOSA supports strategic research which is too tightly targeted for basic research programs, but is still too new, generic, high-risk or long-term for other ministries or industry. MOSA is thus a crucial middle link in an R&D chain stretching from academia to industry. The need for such strategic, "bridging" research has long been underappreciated. Conversely, even moderate investments in such a pivotal area can have extraordinary leveraging power.

MOSA also seeks to increase communication and coordination between the diverse parts of Israel's R&D community. MOSA has formed a nationwide High Commission for the Development of S&T Infrastructure whose 13 members represent the upper echelons of academia, industry and government. They seek to define a national science strategy and specific plans for strengthening research transfer in areas of national priority. This Guide is another MOSA attempt to put the members of Israel's R&D community network "on-line" to each other.

Israel is already exporting its scientific expertise and innovation on a scale scarcely dreamed of a decade ago. If we have the courage to take up current opportunities, the future will be brighter still.

Zvi Yanai
Director-General

Science in Israel

Advanced science and technology are an important part of Israel's cultural, social and economic development. Over 13% of the labor force has university degrees and about 9 out of every 1000 workers are engaged in R&D, compared to 5-6 in the U.S. and Japan. Israel devotes over 3% of its entire Gross National Product (GNP) to research; and education is the largest single item in the national budget after defense. This national emphasis on S&T and the mass immigration of first rate scientists from the former USSR have given Israel one of the highest concentrations of scientists and scientific expertise in the world.

Israeli scientific achievements are internationally respected and widely cited. In 1992, R&D-based industries employed over 100,000 people and accounted for over half of Israel's \$8.8 billion annual exports (excluding diamonds). Israel's rapid growth as an international R&D center derives from a series of fruitful partnerships between the Government, Academia and Industry.

Offices of the Chief Scientists

Ministry of	Phone	Fax
Agriculture	03-9683209	03-997193
Communication	03-5126250	03-5126244
Defense (MAFAT/R&D)	03-6975709	03-216064
Education and Culture	02-292967	02-292223
Energy and Infrastructure	02-316125	02-381444
Environment	02-701596	02-251830
Health	02-705795	02-220468
Industry and Trade	02-220587	02-248159
Labor and Social Admin	03-412166	03-412171
Police	02-309920	02-826769
Science and the Arts	02-847096	02-825581

In Government

The Israeli Government supports science and technology as a key component of national development. The Government's strategy rests on two pillars: **decentralization** to promote initiative, and **coordination** to promote efficiency. In response to a report by Prof. Ephraim Katzir, later President of the State, most government-sponsored research institutions were transferred to the direct control of the Chief Scientists of appropriate "consumer" ministries in the early 1970's. For example, the Israel Agricultural Research Organization (1200 employees) is now part of the Ministry of Agriculture.

This centrifugal tendency is counterbalanced by a variety of coordinating structures, including the Ministry of Science, Technology and the Arts (MOSA). For example, the Minister of Science chairs both the Ministerial Committee for Science and Technology and the Chief Scientists' Forum. The National Council for Research and Development (NCRD), a forerunner of today's MOSA, consists of leading scientists, engineers, industrialists, Chief Scientists and other prominent figures who advise MOSA on science policy and priorities.

MOSA's formal responsibilities include:

- * supporting application-oriented research and manpower development,
- * promoting and implementing international cooperative agreements,
- * approving the appointments of all Chief Scientists,
- * collecting, analyzing and disseminating information on Israeli R&D (this booklet an example),
- * assisting in immigrant scientist absorption.

In general, MOSA sees itself as the crucial "middle link" connecting Israel's basic science and industrial research communities. In practice, this means an emphasis on supporting applied research and

preprototype technology. For example, MOSA's own Fund for the Advancement and Initiation of Basic Research (FAIR) funds about 100 new research projects a year from the 200 proposals it receives annually. Funding is typically \$20-30 thousand a year for 2-3 years. FAIR particularly encourages the early involvement of user-industries, to ensure that FAIR results will actually be used to promote national development.

Often MOSA directly stimulates and coordinates national efforts to develop new scientific initiatives in areas of national priority. For example, high temperature superconductivity was first discovered in 1986. By 1987 MOSA had already formed an ad hoc National HTSC Strategy Committee, which was succeeded by a formal National Committee on HTSC in 1989. Working closely with the Ministries of Industry and Trade (MIT), Defense (MOD) and Absorption (MOA), MOSA helped initiate projects throughout academia and set up a company to help commercialize results. Thanks to these efforts, Israel is set to become a world leader in HTSC-based microwave products. Prototype marketable devices were already on display at the "Second Israeli Conference on HTSC," held with MOSA support in January 1993. Similarly, MOSA and MIT established a National Committee on Biotechnology, and commissioned the influential Katzir Committee Report on Biotechnology (1989), which provided detailed plans for further growth.

In international affairs, MOSA worked closely with the Ministry of Foreign Affairs to establish recent cooperative science agreements with the USSR, Russia, China and India. It also coordinates cooperative research grant programs with the European Community and its member states. For example, the MOSA-BMFT Cooperative

In Government

Program with Germany has funded over 400 projects, worth over \$60 million, since 1974. MOSA also coordinates Israel's participation in the European Nuclear Research Center (CERN), the European Laboratory for Molecular Biology (EMBL) and other international organizations. Domestically, MOSA sponsors a National Genebank with the Ministry of Agriculture, a Laser Ranging Satellite Station at Bar Giora with the Ministry of Energy, a computerized water management system (WATEX) with the National Water Carrier, and many similar interministerial initiatives. The Israel Space Agency (page 40) is also affiliated with MOSA.

MOSA informs the public of its scientific activities through 350 publications, most available free of charge, and a series of electronic newsletters accessible through BITNET (page 53). MOSA's 500 page survey of *Scientific Research in Israel* provides a comprehensive overview of Israel's science-based industries and organizations. MOSA's special programs for immigrant scientists are discussed on page 12. Job opportunities for immigrant scientists in the Government itself are comparatively few and may require a security clearance.

The Ministry of Industry and Trade (MIT) plays a major role in encouraging the development of R&D based industries. It also supports 24 Technology Incubators (page 14), the Israel Institute of Innovation (page 16) and the nine institutes of the Industrial Research Organization (page 38). The Ministries of Health, Communication and Energy each coordinate and promote research in their respective areas. The Ministry of Energy also oversees the three institutes of the Earth Sciences Administration (page 45).

The Center for Absorption in Science (page 13) is part of the Ministry of Immigrant Absorption. The Israel Patent Office (Tel.:

02-316660); is part of the Ministry of Justice. It grants about 2000 new patents each year and publishes a *Patents and Designs Journal* and a *Trademarks Journal* monthly.

Although not a Government Agency, the Standards Institution of Israel (03-6465154) provides standards and technical services to Government and Industry. Their Standards Mark Board issues a Standards Mark, consistent with international ISO-9000 series standards to qualified products. They also have a library of over 400,000 international standards and technical regulations.

n Academia

Israel has over 200,000 university graduates, about 20% of whom work in R&D on a full or part-time basis. Some 40% of Israel's 80,000 university students specialize in science-related fields. Their research activities span almost all areas of modern science (Chapter 15). Professional institutions provide practical training in nursing, engineering, teaching, etc. to another 30,000 students. Although Israel's eight major institutions of higher learning are autonomous, they do receive substantial support -- about half of their operating budget -- from the Government. Basic research is funded by university budgets, private donors and Israel-oriented grants programs (page 49).

Israeli universities are accredited and licensed upon the recommendation of an independent Council for Higher Education (CHE, 02-663133). Its 25 members, 2/3 of whom are senior academicians, are chaired by Israel's Minister of Education. The CHE's influential six-member Planning and Grants Committee (VTAT) recommends and allocates the Government's budget for higher education and academic research.

Israel's universities are quite aware of the need to translate "pure" research results into practical and profitable applications. All have special units for applied research and for commercializing university research results (page 8). These university companies file, hold and license patents arising from university research. They also help publicize commercializable research opportunities and help locate external investors and strategic partners (often Israeli high-tech industries). Topics are similar to those promoted in the Technology Incubators (page 14), in which many universities also participate. The commercialization unit often remains a partner, on behalf of the university, in any new startup companies that are formed. For example, the Technion R&D Foundation's

subsidiaries include Agtech, Biolume, Chaitech, Delitech, Dimotech, Finetech, Franztech, i-Sight, etc.

To give a sense of scale, in 1990 the Hebrew University's R&D company (YISSUM) applied for more than 120 patents and signed 70 contracts with industry, 20 of them R&D service contracts. About half of YISSUM's gross earnings were from overseas.

The Weizmann Institute's R&D company (YEDA) filed 87 patents -- 52 new, 35 foreign extensions -- in 1991. Tel-Aviv University's RAMOT has 180 ongoing commercial projects; and its 70 professional in-house staff work on another 20 preindustrial, research projects. Ben-Gurion University's Advanced Products commercializes everything from microencapsulated insecticides to electrical muscle-activating systems for paraplegics.

Several universities have their own preindustrial applied research funds and/or laboratories that help develop promising innovations to the point where commercial feasibility can be demonstrated. Looking further ahead, many universities have established science-based industrial parks near their campuses, which act as "incubators" for fledgling new high-tech industries (page 16). A sizable fraction of new patents are issued to universities and university "spinoff" companies; but the need to maintain an appropriate balance between basic and applied research remains a continuing policy concern.

The Israel Academy of Sciences and Humanities (02-636211) formally consists of 60 of Israel's most distinguished scientists. The Academy manages the Foulkes Fellowship Fund for junior medical researchers, the Adler Foundation grants for space research, a Fund for Electronics, Computers and Communications and the Wolf Foundation awards. The Academy also

n Academia

administers the programs of the Israel National Science Foundation (Israel NSF), which supports over 400 research grants a year (page 49).

While appreciating Israel's support of applied and industrial research, the Academy has published a series of reports calling for the increased support of basic research as well. It has subsequently raised additional funds for the Israel NSF, from both domestic (VTAT) and foreign sources (such as the Revson and Wolfson

Foundations). Under a new agreement with VTAT, the Israeli Government's funding of the Israel NSF should rise from \$15 million in Academic Year 1993/94 to \$20 million in 1995/96. This, plus \$2 million in private contributions, will make it the largest Israeli program of its kind.

The research programs of individual Israeli universities are highly varied (page 50). They are described more fully in their catalogues and annual research reports, which are available upon request.

Major Israeli Academic Research Institutions

Institution	Campus	Staff	Stud.	Degree	Areas	Phone	Fax
Bar-Ilan U.	Ramat Gan	1000	13,280	BMP	LPS	03-5318402	03-6771088
Ben-Gurion U	Beersheva	780	6,500	BMPR	EHLPS	07-461111	07-281340
	Sde Boqer						
Hebrew U.	Jerusalem(3)	2100	22,250	BMPR	HLPS	02-882111	02-664740
	Rehovot(Agr.)	120				08-481186	08-462181
J.C.T.	Jerusalem	80	400	B	ELP	02-751111	02-422075
Technion	Haifa	1600	9,610	BMPR	E(7*)	04-292111	04-221581
Tel-Aviv U.	Ramat Aviv	1700	22,000	BMPR	EHLPS	03-6408111	03-5414556
U. Haifa	Haifa	790	9,500	BMP	S	04-240111	04-342104
Weizmann I.	Rehovot	475	700	MP	N(6)	08-342111	08-466966

B=Bachelor, M=Masters, P=Ph.D., R=Rofeh (M.D). E=Engineering, H=Health/Medicine, L=Life Science, P=Physical Science, N=Natural Science=L+P, S=Social Sciences, Humanities, Law, etc.

* Plus 8 independent departments (N,E)

Major Israeli Academic Support Institutions

Institution	Campus	Research Authority		Commercialization Unit		
		Phone	Fax	Name	Phone	Fax
Bar-Ilan U.	Ramat Gan	03-5318402	03-6771088	BI/RDC	03-5318441	03-6771088
Ben-Gurion U.	Beersheva	07-461701	07-271612	Advanced Products	07-276420	07-276420
Hebrew U.	Jerusalem	02-754613	02-664740	YISSUM	02-635149	02-660331
J.C.T.	Jerusalem	02-751111	02-422075	JCTech	02-751134	02-751195
Technion	Haifa	04-292576	04-326607	TRDF	04-292111	04-323056
Tel-Aviv U.	Ramat Aviv	03-6409698	03-6409697	RAMOT	03-6428765	03-6429865
U. Haifa	Haifa	04-240111	04-342101	-	-	-
Weizmann I.	Rehovot	08-342111	08-466966	YEDA	08-470617	08-470739

In Industry

Although Israel started with a largely agricultural economy, far-sighted investments in R&D throughout the 1960's and 1970's by the Ministry of Industry and Trade (MIT) and others promoted the rapid expansion of high-tech industries. Between 1969 and 1985 civilian R&D expenditures tripled, and the number of scientists and engineers engaged in industrial R&D increased five-fold. Much of that growth was in electronics, aviation, electro-optics and computers. Although employment growth has slowed since, productivity and exports have continued to climb.

Israel's highly trained workforce and advanced technology helped innovative Israeli products penetrate international markets. Israel's high-tech exports leaped from 15% of its Gross Industrial Product in 1960 to over 54% in 1989. Israel's R&D-based exports jumped from \$2.5 to \$4 billion in 1987-89 alone. Israel's ten largest firms account for over half of her total industrial exports. Electronics (page 18), Computer Software (page 21), Chemicals (page 36) and Defense-related products (page 39) lead the field.

Mirroring today's corporate world, Israel's business relationships are often quite complex. For example, although Elscint is Israel's 20th largest company (\$238 million annual sales) it is 62% owned by Elbit Computers (\$600 million sales), which is 55% owned by Elron Electronics Industries Ltd. (not to be confused with their Elron Technologies Inc. subsidiary), which is 40% owned by two Israeli banks and the Israel Economic Corporation. Elscint itself is traded on the New York Stock Exchange, and has subsidiaries in 13 countries, including the U.S., France, Hong Kong and Germany. These relationships rarely affect the individual employee, and in this Guide we tend to follow public perception in listing separate companies.

In Israel's mixed economy, industrial relationships can also involve the Government or public institutions. For example, the Rafael Armament Development Authority (6000 employees) is under civilian management, and Israel Military Industries (14,000 employees) is an independent company, but both are wholly owned by the Ministry of Defense. Similarly, although the Israel Atomic Energy Commission (IAEC) is part of the Prime Minister's Office, private companies have been set up to commercialize results from the IAEC's Nahal Soreq and Negev Nuclear Research Centers (Isorad and Rotem Ind. respectively). The Koor Industries conglomerate (\$2.7 billion annual sales) which accounts for 10% of Israel's total industrial capacity, is owned by the Histadrut labor federation.

Chartered by a 1985 Law for the Encouragement of Industrial R&D, the MIT Office of the Chief Scientist (MIT/OCS) had a 1993 budget of \$230 million (over twice its 1990 budget). It funded industrial R&D at over 700 companies (twice as many as in 1990), 150 of whom were new startups. Funded projects must be innovative, export-oriented and include appropriate management, production and marketing capabilities. Annual grant repayments do not exceed 2% of royalties a year (\$30 million was received in 1993).

Regular projects receive up to 50% of R&D costs. Those involving 50% new employees or strategic partnerships between two companies may qualify for 60% support up to \$150,000, and 50% thereafter. Larger companies who "adopt" a smaller one can qualify for incubator grants up to \$250,000.

The MIT/OCS also funds industry-university consortia that do cooperative research in such priority "generic technologies" as superconductivity, satellite communications, VHDL (Hardware Description Language), genetically-engineered seeds, ligand recep-

tors, gallium arsenide semiconductors, and submicron electronics. Grants are typically \$5-6 million, and cover up to 66% of generic R&D costs. In contrast, product and process improvement and military export grants are limited to 30% MIT/OCS participation. Other programs promote product commercialization (30-50% of prototype and licensing costs) and R&D subcontracts from foreign firms (20% support). There are also small grants for academic preindustrial R&D and for feasibility studies.

Computer Software (21%), Electronics/Electro-optics (26%), Chemistry (12%) and Telecommunications (9%) are the major MIT/OCS recipients. page 14-15 describes the MIT's "Technology Incubator" Program for immigrant scientists.

The U.S.-Israel Binational Industrial R&D Fund (BIRD) uses repayments and the interest on its \$110 million endowment to share up to 50% of the R&D costs for new joint U.S.-Israel industrial ventures. Projects vary from \$200,000 to \$2.5 million in size and usually combine Israeli technical innovation with U.S. marketing expertise. Successful projects eventually repay up to 150% of the grant. In 1992 these profit-sharing repayments amounted to \$4 million of the BIRD's \$12 million annual budget.

Mini-projects (\$200,000 or less) need only the Executive Director's approval, whereas full-scale projects (average budget \$1 million) require board approval. Only existing high-tech civilian industries are eligible. Since 1979 the BIRD has invested over \$90 million in around 300 projects. BIRD projects have led directly to over \$3 billion in new sales.

The Israel Export Institute (IEI, 03-5142830), the Manufacturer's Association of Israel (03-5128787), the Israel Industry Center for R&D (MATIMOP, 03-5175930) and the Kibbutz Industries Association(03- 6955413) also help promote Israeli industrial products

and interests. The IEI publishes an excellent series of corporate profiles in specific areas (electronics, biotechnology, etc.); and MATIMOP publishes a newsletter, *Advanced Technologies from Israel*.

Israel's favorable R&D climate has led to significant R&D investment by over 150 foreign companies. Many prominent U.S. firms, such as Intel, IBM, and Motorola, now have Israel-based subsidiaries. Conversely, many Israeli companies are listed on foreign stock exchanges and have overseas subsidiaries. Finally, free-trade agreements with **both** the U.S. and the European Community give Israeli-made products preferential treatment in **both** mega-markets. In 1990, exports to the EC (34%) finally topped those to the U.S. (29%).

The Israeli R&D-based industrial sector is in constant flux. Every year brings a large crop of new small high-tech industries. These are usually based on one or two particularly innovative products or ideas and a very small (1-5 person) staff. Some grow rapidly while others disappear, merge or reform. They are often looking for new, often temporary, employees (there is little ability to absorb new contracts in existing staff); but there are also often risks (there may be insufficient capital to weather prolonged financial crises). At the best new employees will grow rapidly with the firm. At the worst, they will need to find new jobs in a year or so, albeit with much useful new experience. Large companies often shift their priorities and staffs to meet new market realities. Specialists frequently find themselves switched, perhaps after some retraining, into new technical areas.

Mid-level salaries tend to be higher in industry than in government or academia. Beginning salaries tend to be low in all three sectors. More detailed information on Israeli industries can be found in local Chamber of Commerce libraries.

n Industry

City	Address	Phone
Beersheva	7 Hamuchtar Street	07-280774
Haifa	53 D. Ha'atzmaut	04-626364
Jerusalem	10 Hillel Street	02-254333
Tel-Aviv	84 Hahashmonaim	03-5631010

Israel 20 Largest R&D-Oriented Companies

Company	Sales*	Staff	Products
Israel Electric Corp.	592	11,700	Electricity
Israel Aircraft Ind. (IAI)	447	16,450	Aircraft, Electronics
Tadiran	785	7,110	Electronics, Appliances
Scitex Corp.	623	2,880	Computerized Printing
Elbit Computers	600	4,000	Computer-based Systems
Dead Sea Works (DSW)	549	2,925	Dead Sea Chemicals
Motorola Israel	526	3,025	Communications, Electronics
Teva Pharmaceuticals	502	3,120	Pharmaceuticals, Chemicals
Vishay Israel	451	6,000	Electronics Equipment
Dead Sea Bromine Group	329	1,490	Dead Sea Chemicals
Rotem Amfert Group	298	1,165	Fertilizer, Chemicals
ECI Telecom	296	1,760	Telecommunications
Intel Electronics	293	750	Integrated Circuits, VLSI
Telrad Telecommunications	281	2,500	Telecommunications Systems
Elta	272	2,430	Defense Electronics
Elscont	238	1,700	Biomedical Imaging
Haifa Chemicals	189	600	Fertilizers
Makhteshim Chemicals	184	985	Agricultural Chemicals
Iscar	177	1,200	Metal Tools
Agan Chemical Man.	150	550	Agricultural Chemicals

Note: Dead Sea Bromine Group, Elta and Elscont are subsidiaries of DSW, IAI and Elbit, respectively.

* 1993 sales in \$ million

A

liyah and Absorption

Although scientists are comparatively mobile, their highly-specialized experience, devotion to their field and need for expensive equipment can complicate their absorption into a new home. The problem is compounded when the immigration (aliyah) is large and the recipient country small. For example, 450,000 immigrants, 9000 scientists and 50,000 engineers have arrived in Israel (total population 5 million) since late 1989. The resulting increased demand for goods and services has led to dramatic economic growth (over 6% in 1992); but the problem of absorbing so many newcomers has been equally dramatic.

The absorption of Russian immigrant scientists is particularly complex. For example, almost half are physical scientists or mathematicians. Only a quarter are in the life sciences, and even fewer are in the social sciences. In Israel the employment pyramid is reversed. In Russia, most scientists worked in government-sponsored research institutes. Fewer worked in university laboratories; and virtually none worked in the private sector. Here again conditions in Israel are precisely the opposite. Israel's rapidly growing high-tech industries are able to absorb new arrivals, but comparatively few Russians have experience in these areas. Even fewer have the entrepreneurial and marketing skills needed to set up their own new R&D-based industries. Indeed the vigorous competition that characterizes all Israeli (and Western) life -- whether getting a job, a grant or a customer -- may seem daunting to scientists not raised in a free market economy.

The Government has provided considerable short and medium-term aid. Still, even with Government subsidies, no more than a third of the incoming scientists can be absorbed into basic academic research. At present, 6000 of Israel's 9000 immigrant scientists have found S&T-related employment, albeit

often outside their original specialty. Of these, 3500 work in private industry; and 700, in Government-sponsored technology incubators. The outlook for their stable, long-term employment is high. Many of the 1500 immigrants doing research in universities, however, are on "soft money" (grants and short-term contracts), which must be renewed or replaced periodically. Another 300 immigrant scientists work in private and Government research institutes, hospital laboratories, etc. The remaining 3000 are either still in Ulpan (language training), work at nonscientific jobs or are unemployed. About 1000 of these are unlikely to find research-related jobs due to the lack of sufficient scientific skills. In contrast, researchers at the upper end of the spectrum, which includes some of Russia's top scientists, have readily found employment.

The Ministry of Science, and the Arts (MOSA) has been particularly active in promoting scientist absorption. Even before Government funds became available, MOSA raised \$1 million of private funds to start pilot immigrant training and research programs. MOSA initiatives formed the basis of Program 2000, a comprehensive interministerial program to absorb new scientists. MOSA's current absorption program (\$6.5 million) includes:

1. **Immigrant Research Grants Program.** MOSA has already received over 1000 submissions and funded over 400 immigrant research projects, through its FAIR program (page 5). Successful grantees typically receive \$20,000 a year for 3 years. Research results have been excellent.
2. **Absorption at Regional R&D Centers.** These centers promote integrated regional development using local resources. MOSA has already begun strengthening and absorption programs at several centers.

A

liyah and Absorption

3. **Expanding Bachelor of Technology Programs** at Israel's smaller technical colleges, especially those outside large urban centers.
4. **Scholarships** for completing Ph.D. degrees. MOSA provided 50 such scholarships in 1993 from its own funds, and 20 more with funds provided by the Rich Foundation.
5. **Seminars** in Israel and throughout the former Soviet Union (from Moscow to Nyzhny-Novgorod to Byshkek) on science and research-related employment and conditions in Israel.

MOSA also sponsors KLITEX, a computerized employment exchange for immigrant scientists and Israeli high-tech industry. KLITEX accepts curricula vitae from immigrant scientists and engineers seeking employment and circulates them electronically among interested employers. A set of 600 keywords and subclassifications ensures a close match between needs and expertise. Over 6000 scientists have applied, and 1600 have already found jobs through KLITEX. About 60% of the applicants have the equivalent of M.S. degrees; over 30% have doctorates. There is no charge for this service to either the applicant or the employer. KLITEX can also be reached by telephone (02-847661) or FAX (02-820591).

The Center for Absorption in Science (02-752744), is part of the Ministry of Absorption (MOA). It provides individual counseling on S&T employment, and also helps pay for 80-85% of the first and (often) second year salaries of selected immigrant scientists. Applicants must have a Ph.D., M.Sc. or M.D. plus prior research experience. The Center has an excellent record for initial immigrant placement (over 30%). Other sources of job information are the Classified Ads section of Friday newspapers and -- most important -- word of mouth. Immigrants should contact as many

professionals in their field as possible, a technique known in the West as "networking," and make their availability known.

MOSA recently initiated a series of ambitious "Big Projects" as a joint venture with the MOA. Under the first such project, Decision Systems International (DSI, page 40) is hiring and training 100 immigrant scientists, with Government support for one and a half years; DSI is committed to hiring them thereafter. The new commercial software that the immigrant experts are developing should help the program pay for itself. This project will absorb new immigrant scientists at a fraction of the cost of traditional aid programs; while generating permanent new jobs for the participants. More recently, Microdata has begun hiring 50 immigrant scientists under similar terms; and negotiations with Rad Data and Softel are almost completed.

MOSA and MOA also jointly sponsored a National Planning Committee for the Long-Term Absorption of Immigrant Scientists, involving representatives of ten other ministries, academia, and industry. MOSA Division of Social Sciences and Economic Research has been commissioning research on the absorption of new immigrant scientists. Recent results, based on several hundred file reviews and 100 personal interviews, indicate that many traditional assumptions must be revised in designing new programs.

The Ministry of Industry and Trade (MIT) provides incentives for hiring new immigrants in industry and in its own research institutes (page 38). Among immigrant scientists, the MIT is best known for its highly successful Technology Incubators (TI) which are spread throughout the country (nine are south of Jerusalem, four are north of Haifa). The TI help start new businesses based on immigrant technical

A *liyah and Absorption*

innovation. They provide administrative and technical assistance, low-cost facilities, and business guidance. They also help locate strategic partners and outside capital. The TI already support over 210 MIT-approved projects involving over 1000 immigrant scientists.

All are expanding, and more are planned. The goal is 30 incubators with 250 active projects employing 1000 researchers (80% immigrants) by early 1994. Computer software, electronics and electro-optics are the most prominent specialties, reflecting the well-known Russian expertise and Israeli commercial interest in those areas. Some TI specialize (e.g. Am-Shav and Jerusalem Software) while others accommodate a wide variety of topics. For example, the Scientific Incubator, one of three TI's located in Jerusalem's Har

Hotzvim Industrial Park, includes projects on the detection of bacteria in body fluids, photochromatic lens coatings, infrared communications systems, an ultra-compact CO₂ laser, and an eight-language word processor. Technion TI projects include new ceramics for electronics applications, an ultrasonic hardness tester, a sprayer for thick canopy row crops, a TCL metabolism diagnosis monitor and educational software for children. Kiryat Weizmann TI projects include ferroelectric liquid-crystal light modulators, electric food quality control monitors and advanced software tools. Patir TI projects include a mammography diagnosis workstation, a computerized system for recognizing vehicle license plates, and a submicrolithography system for producing better integrated circuit chips. A useful "snapshot" of the program as of

Technology Incubators

Incubator	City	Tech. Support	Phone	Fax
Advanced Tech.	Dimona (Temed)	Ben-Gurion U	07-558631	07-556106
Am-Shav	M.Ben Gurion	Ben-Gurion U.	07-558292	07-558352
Arad	Arad	Motorola	07-952579	07-952693
Ashkelon	Ashkelon	Partners	07-711853	07-711852
Eltam	Haifa	Elron/Matam	04-550484	04-550372
Gat	Kiryat Gat	Ben-Gurion U.	07-811762	07-811763
Golan	Katzrin	Partners	06-962561	06-962564
Granot (Yozmot)	Hefer	Partners	06-870203	06-870205
Har Hotzvim (Bus.)	Jerusalem	Hebrew U.	02-812380	02-812386
Jer. Software	Jerusalem	Malam	02-870012	02-870015
Maytav	K. Shmona	Migal Galilee	06-953556	06-944980
Misgav (Carmiel)	Misgav	Rafael	04-906793	04-906355
Mofet B'Yehuda	Kiryat Arba	Partners	02-963880	02-961571
Naiot	Nazareth Ilit	IMI	06-500764	06-578058
Negev (ICN)	Beersheva	Ben-Gurion U.	07-231212	07-231246
Ofakim	Ofakim	Ben-Gurion U.	07-925580	07-926581
Patir R&D	Jerusalem	Jer.Col.Tech.	02-751123	02-422075
Rad-Ramot	Tel Aviv	RAD, TAU	03-6408113	03-6429865
Scientific TI	Jerusalem	Hebrew U.	02-870203	02-870205
Soreq (Titzanim)	Yavne	Isorad	08-434415	08-434798
Technion	Haifa	Technion	04-308333	04-210531
Kiryat Weizmann	Nes Ziona	Weizmann I.	08-409086	08-408085
Western Negev	Neve Dekalim	Partners	07-847687	07-847361
Y.T.B	Ariel	Judea & S.Col.	03-9364754	03-9366873

Aliyah and Absorption

February 1993 is provided by the MIT's 190-page publication *Technological Incubators in Israel*.

Each TI is responsible for selecting its own areas of interest, R&D projects, initial products, investigators and evaluation teams (subject to MIT approval). Each TI must be able to accommodate at least 10 projects and 50 immigrant investigators. The MIT provides up to NIS 325,000 a year for the TI's operation (100% expenses), and up to NIS 300,000 a year per project (100% of salaries, 75% of other expenses). The goal is to produce R&D-based, export-oriented

enterprises, which can attract outside investment within two years. If the project is a commercial success, it must pay back 2% of gross sales to the TI through the MIT until the initial investment is repaid. MOSA has also been supportive of the TI program, and has helped locate qualified immigrant scientists through its KLITEX database.

Interested investigators should send a brief project proposal (abstract) and curriculum vitae directly to the TI's of their choice. However, they should first contact the individual TI's to see if their proposal falls within current interests and priorities.

Approved Incubator Projects*	Agrotechnology	Biotechnology	Biomedical Eng.	Chemistry	Computers	Electronics	Electro-optics	Energy	Eng./Instrumen.	Health Care	Materials	Total
Advanced Tech	-	1	-	1	7	-	1	-	3	-	2	15
Am-Shav	-	-	-	-	6	-	-	-	-	-	-	6
Arad	-	-	-	-	1	-	1	-	-	-	-	2
Ashkelon	-	-	1	-	1	-	4	-	1	-	-	7
Eltam	-	-	-	-	3	1	-	-	-	1	1	6
Gat	-	-	-	1	-	2	-	1	1	-	1	6
Golan	-	-	-	3	2	-	1	-	2	2	1	11
Granot (Yozmot)	-	1	1	1	1	2	-	-	2	-	1	9
Har Hotzvim (Bus).	-	-	1	-	1	-	-	-	2	-	-	4
Jer. Softwar	-	-	-	-	3	-	-	-	-	-	-	3
Kiryat Weizmann	-	-	-	1	1	-	1	-	3	-	-	6
Maytav	2	-	-	-	-	-	-	-	-	-	1	3
Misgav	1	-	-	-	-	-	-	-	2	-	1	4
Mofet B'Yehuda	-	-	-	-	3	-	-	-	1	-	1	5
Naiot	1	-	3	-	-	-	-	-	-	2	-	6
Negev	-	-	-	-	1	2	-	1	3	-	1	8
Ofakim	-	-	1	1	-	-	-	-	3	-	-	5
Patir	-	-	1	-	5	1	3	-	1	-	-	11
Rad-Ramot	-	-	1	-	-	-	-	1	1	-	-	3
Sci.Incub. (Jer)	-	-	-	-	2	-	2	1	-	2	1	8
Soreq	-	-	-	-	-	-	-	-	1	-	-	1
Technion	1	1	3	-	1	2	2	-	1	-	-	11
Western Negev	-	-	1	-	-	-	-	-	1	1	-	3
Y.T.B	-	-	-	-	-	1	-	-	-	1	-	2
TOTAL	5	3	13	8	38	11	15	4	28	9	11	145

*As of February 1993 .Eng.=Engineering

Instrumen.=Instrumentation

Progress: A Partnership

The remarkable growth of Israel's high-tech industry derives from a fruitful partnership between its university, government and industrial communities. This is particularly evident in Israel's science-based industrial parks. These industrial "science cities" are usually located near major university campuses. The Government often provides investment incentives, loans and tax benefits to industries moving into the parks. The university often provides oversight, technical expertise and advanced research facilities. Conversely, the parks' industries often provide supplementary jobs and subcontracts for university faculty and graduates. Many parks have fully developed infrastructures including banks, stores, day care centers and recreation areas; but employees live off-campus and commute to work. Candidate firms are screened for admission.

Most parks are large and still growing. Har Hotzvim (Jerusalem), for example, is expanding to 87 acres, 6000 people and \$1 billion in sales. The parks particularly benefit small new enterprises. As companies grow, their production facilities are often moved to "satellite" parks or heavy industrial zones. Many parks also serve as homes for the MIT's Technology Incubators (TI) for immigrant scientist entrepreneurs (page 14). Each TI is an independent public organization (amouta) with its own buildings, management and staff. TIs are often organized by local municipal authorities, such as the Jerusalem Development Authority (JDA), and take advantage of the technical expertise of nearby industries and universities. In short, all three sectors (government, academia, industry) are active participants.

The Israel Center of Innovation (MESER: 03-614-525) helps scientists implement new ideas. For example, MESER and MOSA

helped a group of Russian immigrant scientists develop a new lead-acid battery at Bar-Ilan U. The Israeli Industry Center for R&D (MATIMOP; 03-650150) helps match young companies (many from TIs) with more established Israeli and foreign companies in joint ventures.

The National Center for Scientific and Technological Information (COSTI; 03-492078) maintains a variety of local and international electronic databases and publishes lists of Israeli industrial laboratories, technical associations, and scientific meetings. The Israel Export Institute (03-5142830) is known for its useful set of publications, which promote particularly active areas of Israeli high-tech industry.

Other useful numbers include: the Israel Development Corporation (03-430611) which invests in companies developing and marketing new science-based products, and the Scientific Research Foundation (02-534515) which funds energy R&D projects.

Most universities have Departments of Applied Research and commercialization units (page 8) which pursue industry-related research.

Pages 18-46 list, by technical area, Israel's largest industrial, university and government organizations. The omission of most smaller or less R&D-intensive companies (those with fewer than 10-15 R&D staff) is merely a practical matter, due to space limitations. A complete listing will be found in MOSA's comprehensive 550 page publication.

Scientific Research in Israel (SRI). Similarly, although brief examples of ongoing research projects are included, that is not to imply that equivalent or superior research is not being done elsewhere. Occasional sales, export or employment figures are included to give a sense of scale. Inclusion of a firm

*P*rogress: A Partnership

does not imply MOSA approval or the availability of employment.

To save space, alphabetic codes are used to describe subareas (see the bottom of the charts) and many common terms are abbreviated. For example:

C. = Center (of/for)
 Div. = Division
 En. = Energy
 Eng. = Engineering
 Ind. = Industry
 Int. = International
 Inst. = Institute
 K. = Kibbutz
 R.C. = Research Center
 Res. = Research
 Sys. = System(s)
 Tech. = Technology
 U. = University

The "R&D" column lists the number of R&D staff in all fields. When this is unknown, the total staff is given in (). The reader will note many changes from the 1991 edition of the Guide, further testimony to the remarkable fluidity and dynamism of Israel's high-tech industrial scene. We have also included FAX numbers to promote written communication. In case of telephone number changes (frequent in Israel), contact the Information Operator (dial 144) in the city listed. Numbers are listed as they would be dialed in Israel. Overseas callers should replace the initial 0 with 972, Israel's country code.



Electronics and microelectronics were the first and largest success of Israel's high-tech revolution. Israel sold almost \$4 billion of electronics-based products in 1992, including \$2.6 billion of exports (up from \$0.5 billion ten years ago). Growth has been steady at around 10% for many years. The electronics industry, now accounts for over one-third of all Israeli exports, and over 30,000 jobs, including over 10,000 scientists and engineers, and 8000 technicians. Conversely, electronics absorbs over half of all Israeli industrial R&D investments, although much is invested in new equipment and facilities rather than in increased employment.

Israel's largest industries are highly active in this area. Israel Aircraft Industries (\$1.45 billion in sales) has a 6200 person Electronic Division which includes such firms as Elta, MBT, MLM and Tamam (page 41).

Tadiran's 6800 employees generate \$780 million a year in sales, of which \$40 million is reinvested in R&D. Subsidiaries include Elisra, Contahal and ATL. Elron Electronics Industries subsidiaries include Elbit, Elscint, Fibronics, Orbotech, Rosh, Elor and Chip Express. Although smaller companies successfully develop specialized products and services, high startup costs limit most microchip production to large firms (mostly foreign subsidiaries).

In 1992, telecommunications-related electronics accounted for about 27% of all sales; industrial and medical systems 20%; and defense-related systems, 40%. Most electronics companies have registered impressive gains in the last few years, despite the international decline in defense purchases. Russian immigrant scientists continue to do well in this field, especially in applications involving advanced semiconductor physics.

Integrated Circuits, VLSI. The heart of modern computers is the solid-state microprocessor, an array of hundreds of

semiconductor devices and circuits etched or deposited onto the coated surface of a small semiconductor "chip." Many important U.S. firms have set up highly successful Israeli subsidiaries to design and manufacture ever smaller and more powerful very large scale integrated (VLSI) microprocessors and circuits.

Intel Israel (\$235 million exports) developed the math coprocessors for Intel's landmark 286 and 386 chips, and software for the Pentium chip, which contains over 3 million transistors. Some 10-15% of Intel's new hires are Russian immigrant scientists. National Semiconductors (Israel) developed the world's first 32-bit microprocessor in 1983, and the first application-specific microprocessor for laser printers in 1989. Their new TyIN2000 system combines modem, FAX, voice and answering machine capabilities into a board which any consumer can plug into their PC. Quick Technologies' automated systems can design and cut low-cost gate array prototypes in one day. Motorola, Zoran Microelectronics and See Technologies are also subsidiaries of larger U.S. firms. Most are doing very well indeed; for example, sales for Motorola and Intel were both up 30% in 1993.

DSP produces chips for cellular and cordless telephones and digital answering machines. Over half their chips are sold to Japanese firms. i-Sight's VLSI-based systems use digital image capture and processing to provide high-resolution images for medical and industrial applications. Opal's first and second generation automated systems for producing integrated circuit chips are industry standards. KLA Israel's coherence probe metrology system measures the precise dimensions of devices on semiconductor chips. Over half of the systems are shipped to Japan and Korea; about a quarter, to the U.S.

Electronics

Defense and Security. Elta specializes in ground and airborne radar; MBT, in missile fire control. Elisra's 1300 person technical staff does advanced research in defense and electronic warfare systems (Chapter 12). Visonic produces detectors, wireless equipment and digital systems for the security industry.

Telecommunications. Israel's telecommunications industry is among its fastest growing sectors. Exports were up 47% in 1992 alone. R&D-based applications include the digitalizing, processing, transmission and enhancement of images, speech and data.

ECI Telecom (\$295 million sales) specializes in speech coding, compression and processing systems. Their Digiloop system allows existing telephone lines to transmit four calls at once. They recently agreed to sell Germany \$71 million of multiple-use fiber optics communication lines. Telrad (\$281 annual sales) makes central office digital exchanges that can handle 100 to 100,000 lines, digital PABX's and ISDN terminals. Motorola Semiconductors'

MS68302 ISDN communications chip contains over a half million transistors. Gilat Satellite Networks and Misat design VSAT communication satellite earth station and hub equipment. Elisra's civilian products include data terminals for satellite communications, wireless PABX systems and digital medical imaging. Bezeq, the national telephone company, is slated for privatization.

Universities. Most Israeli universities support research on the basic physical and electrical phenomena underlying microelectronic devices in their Applied Physics or Electrical Engineering Departments. Typical topics include: semiconductors, integrated circuits, VLSI, signal recognition and signal processing and network theory.

Societies/Networks. Many electrical engineers belong to AEAI (page 43). Many manufacturers belong to the Association of Electronics Industries (03-663986). MOSA's Microelectronics newsletter can be accessed through BITNET (page 53).

Major Israeli Organizations in Electronics

Organization	Code	R&D	City	Phone	Fax
Applied Materials	a	30	Tel Aviv	03-6450201	03-6450280
Arco Electronic Control	bde	34	Rishon Lezion	03-9630844	03-9614675
AVX	abe	15	Jerusalem	02-819707	02-815999
Bezeq	e	200	Jerusalem	02-395273	02-255522
Digital Equipment	ae	70	Herzlia	09-544255	09-593222
ECI Telecom	e	152	Petach Tikva	03-266555	03-9266700
Efrat Future Tech.	de	200	Tel Aviv	03-5131313	03-5131309
Electo Galil	d	15	Kiryat Shmona	06-951788	06-951432
Elisra Electronic Sys.	b-e	(1000)	Bnei Brak	03-7545560	03-7545468
Elop Electro-Optics	cd	300	Rehovot	08-386211	08-386826
Elta Electronics Ind.	cd	1200	Ashdod	08-572581	08-564568
Eltek	a	(200)	Petach Tikva	03-9308635	03-9309581
General Microwave	c	25	Jerusalem	02-783925	02-782460
Gilat Satellite Networks	e	30	Tel Aviv	03-499068	03-5447429
i-Sight	a	16	Zichron Yaakov	04-397336	06-396307

Major Israeli Organizations in Electronics

Organization	Code	R&D	City	Phone	Fax
Intel Electronics	a	--	Jerusalem	02-897111	02-897677
Intel Israel	a	300	Haifa	04-655711	04-655999
Keren Electronics	b-d	20	Lod	08-273170	08-273173
KLA Instruments Israel	a	30	Migdal Haemek	06-542987	06-543136
Koor Commun. & Sec.	e	15	Tel Aviv	03-5483311	03-492188
Lipman Electronics	ab	14	Tel Aviv	03-493945	03-497719
Microelectronics	abc	11	Rishon LeZion	03-9612329	03-9612307
Microkim	cd	30	Haifa	04-511211	04-551218
Misat	e	10	Haifa	04-550145	04-550147
Motorola Israel	ade	1100	Tel Aviv	03-5658888	03-5624925
National Semiconductor	a	160	Herzlia Bet	09-594255	09-558322
Opal Technologies	a	36	Nes Ziona	08-408222	08-409902
Optomic Technologies	c	25	Migdal Haemek	06-545440	06-545382
Orbotech Ltd.	a	180	Yavne	08-423533	08-438769
Phasecom	ce	20	Jerusalem	02-825555	02-824571
Quick Technologies	a	18	Haifa	04-550011	04-551122
Rad Data Commun.	e	150	Tel Aviv	03-6458458	03-498250
Rad Network Devices	e	28	Tel Aviv	03-5447361	03-5447146
Savin Electronics	ab	12	Petach Tikva	03-9211090	03-9241715
Tadiran	ade	700	Holon	03-5577731	03-5564474
Taas-Hancal Sys. Eng.	de	50	Ramat Hasharon	03-5484355	03-5484300
Team Telecon Inc.	e	40	Givat Shmuel	03-343471	03-343917
Telkoor	d	30	Holon	03-5575665	03-5575286
Telrad Telecom. & Elec.	e	300	Lod	08-275555	08-254760
Time & Frequency	be	30	Holon	03-5574107	03-5574114
Vishay Israel	b	(2700)	Holon	03-5569595	03-5568116
Zoran Microelectronics	ae	33	Haifa	04-551551	04-551550

Universities and Government

Organization	Code	R&D	City	Phone	Fax
Ben Gurion U.	abe		Beersheva	07-461111	07-281340
Hebrew U.	abe		Jerusalem	02-882111	02-664740
Jerusalem Coll. Tech.	a-e		Jerusalem	02-751111	02-422075
Technion	abe		Haifa	04-292111	04-221581
Microelectronics RC	a		Haifa	04-293262	04-221581
Res. C. for VSLI	a		Haifa	04-293233	04-221581
Tel Aviv U.	abe		Ramat Aviv	03-6408111	03-5414556
Weizmann Inst.	c		Rehovot	08-342111	08-466966

a Microelectronics; integrated circuits, microprocessors, printed circuits, VLSI ■ b Power supplies, components ■ c RF, microwave systems ■ d Defense, security systems ■ e Telecommunications, signal processing, networks.

C omputers

The computer revolution has created a worldwide market for innovative software. This is the basis of a rapidly expanding Israeli industry generating over \$600 million in sales and 12,000 jobs. Software exports have leaped from \$8 million in 1985, to \$135 million in 1992. Growth now averages 20% a year. Software company startup costs are low, and the payoff for innovation is high; thus new entries abound.

Israel now has around 150 software-related firms, many of them comparatively small. These offer prospective employees unique advantages and disadvantages (page 10). Russian immigrant experts have done well in this field, particularly in applications involving advanced mathematics and image processing. MIT/OCS has expressed special interest in advanced research in CAD/CAM, voice processing, expert systems, software and output systems.

Computer Hardware, Peripherals. Almost all Israeli computers are imported or just reassembled from imported parts; but innovative smaller peripheral systems are widely available. Adacom Technologies produces multiplexers, protocol converters and communication controllers for the IBM 3270 environment. Intelligent Information Systems (IIS) designs and manufactures communications and network peripherals for IBM mainframe and midrange computers. Their sales more than doubled in 1993. MLL's computerized billboards can display data, graphics and animation at more than 24 pictures a second.

Software Engineering, Advanced Languages. Advanced Technology, Israel's largest software engineering firm, makes software tools that help design, test and improve other software. Fourth Dimension's EAO software automates and improves the operations of mainframe computers. Magic Software's totally code-free, post-4GL applications development system is now used by over

150,000 programmers worldwide. MLL produces a wide variety of software tools, including an innovative object-oriented applications generator.

CAD/CAM, Automation, Robotics. Using computer-aided design (CAD), new products can be designed, tested and modified on the computer screen before proceeding to computer-aided production engineering (CAPE) and manufacture (CAM). Tecnomatix is a leader in CAPE systems that help design, simulate and optimize the operation of individual robots or entire automated manufacturing systems. Their Robcad programming tools help control automatic painting, drilling, laser cutting and spot-welding. Cubital's Solider 5600 system turns computer-generated images into real 3-dimensional models. Orisol produces an industrial robot that sews shoe "uppers" using a computer vision edge-following system.

Orbotech is a world leader in the automatic manufacture and inspection of computer chips and printed circuit boards (Chapter 10). Eshed Robotec produces educational robots and is developing an industrial robot together with a Japanese firm. SEE Technologies Visual HDL is a graphical hardware-design system. Rosh software helps automate the servicing of expensive industrial equipment by diagnosing and resolving performance problems.

Data Communications. Lannet produces data communications systems for both local-area (LAN) and wide-area (WAN) networks. One product enables standard networks to run multimedia (data/audio/video) applications. Rad Data Communications produces high-speed multiplexers for data/voice/FAX/LAN traffic. Developers of the world's smallest modem, they also produce remote-access telecommunication systems that link home computers and laptops with LANs. Annual sales for each company are

C

omputers

\$50-60 million. ACE/North Hills provides internetworking solutions and multiplexers for IBM 3270 and LAN environments, and is a leading supplier of data calling systems to IBM. Manof's multinetwork information-switching systems include an innovative communications platform for banks.

Education. Edunetics' Rediscover Science/Mathematics educational systems are already used by over 250,000 American students and throughout Israel. They do R&D in microcomputer animation, data storage and network technologies.

Publications. Scitex (\$623 million sales) is a world leader in computerized color graphics, publishing and printing systems. Its 250 person technical R&D staff also develops related products, such as laser film plotters and CCD color separation scanners. Indigo has developed an innovative high-speed, digital color offset printer, that can produce 4000 pages/hour with 800 dots/inch resolution. They also produce the world's fastest plotters for engineering drawings.

Defense, Security. Computers play an important role in many defense systems.

Large firms, such as Elbit, Elron, MBT (Israel Aircraft) and Tadiran, account for most of this effort (page 39).

Universities. Most Israeli universities have active computer science programs in their Applied Mathematics and/or Electrical Engineering Departments. There is considerable theoretical research on advanced algorithms, coding and control theory, graph theory, artificial intelligence, computer architecture, expert systems, operating systems, CAD/CAM, interactive graphics, robotics and scientific applications. The Technion has a separate Center for Applied Computer Research. IBM Israel also supports joint research with academia.

Societies/Networks. Many computer scientists belong to the AEAI (page 43). There is also an Israel Mathematical Union (c/o Hebrew U). MOSA maintains an electronic newsletter in Computer Sciences on BITNET (COMP-SCI@TAUNIVM). The Israel Association of Software Houses (03- 5129836) serves as liaison between local industries and potential clients.

Major Israeli Organizations in Computers and Robotics

Organization	Code	R&D	City	Phone	Fax
ACE/North Hills Israel	ai	25	Yokneam	04-892902	04-892743
Adacom Technologies	ab	42	Yokneam	04-892444	04-894212
Advanced Technology	b,d-g	(400)	Tel Aviv	03-5483555	03-499990
Afcon Projects	cd	20	Petach Tikva	03-9392333	03-9244249
Cimatron	c	30	Givat Shmuel	03-5715171	03-5713062
Com Software Indus.	bf	35	Ramat Gan	03-7516434	03-7520189
Contahal	cdfg	15	Givatayim	03-5715111	03-5715127
Contel Control & Instr.	d	40	Tel Aviv	03-6954162	03-6958678
Cubital	c	15	Raanana	09-906888	09-919937
DCL Technologies	beg	(115)	Herzlia	09-584684	09-543917
Decision Systems Israel	bg	330	Givat Shmuel	03-5313333	03-5313322
Degem Systems	e	20	Tel Aviv	03-494971	03-494968
E.L. Computers	ef	45	Tel Aviv	03-5661155	03-5661177
Edunetics	e	50	Herzlia	09-575133	09-575160
Electronic Imaging Tech.	ac	20	Herzlia Bet	09-582525	09-583999

C omputers

Major Israeli Organizations in Computers and Robotics

Organization	Code	R&D	City	Phone	Fax
Eshed Robotec	d	26	Tel Aviv	03-498251	03-498889
Expert System Ind.	dfg	16	Ramat Efal	03-343476	03-346897
Fibronics	a	70	Haifa	04-313313	04-550550
4th-Dimension Software	b	90	Tel Aviv	03-491211	03-491002
Hilan	b	30	Tel Aviv	03-5122222	03-370088
IBM Israel	a-i	94	Haifa	04-296211	04-550070
Indigo	acf	100	Rehovot	08-381818	08-408091
Intel Israel	cd	300	Haifa	04-655711	04-655999
Intelligent Info. Sys.	a	40	Yokneam	04-892077	04-892079
Koor Commun. & Sec.	f	15	Tel Aviv	03-5483311	03-492188
Lannet Data Commun.	ai	110	Tel Aviv	03-6458458	03-5447146
Lanoptics	i	15	Migdal Haemek	06-546222	06-540124
Magic Software	b	45	Givatayim	03-5715111	03-5715127
Malam Systems	b	200	Jerusalem	02-707611	02-707838
Manof Commun. Systems	f-i	25	Herzlia	09-594888	09-594889
Mashov Computers	b	15	Ramat Gan	03-7511914	03-7516218
MLL Software & Comp.	abef	50	Tel Aviv	03-5656821	03-5613457
National Semiconductor	bc	160	Herzlia Bet	09-549255	09-558322
Orbotech Systems	d	180	Yavne	08-423533	08-438769
Orisol Original Sol.	d	15	Rishon Letzion	03-9616526	03-9618984
Product Computers	b-f	38	Haifa	04-335565	04-335564
Quick Technologies	d	18	Haifa	04-550011	04-551122
Rad Data Commun.	ai	150	Tel Aviv	03-6458181	03-498259
RAD Network Devices	a	20	Tel Aviv	03-6458458	03-5447146
Ready Systems	bc	(30)	Beit Gamliel	08-432128	08-432128
Robomatix Tech.	abd	20	Raanana	09-986976	09-986980
Rosh Intelligent Sys.	b	20	Jerusalem	02-344052	02-344058
Scitex	acf	250	Herzlia Bet	09-529222	09-559810
SEE Technologies	ac	40	Herzlia Petuah	09-584684	09-543917
Team Telecon Inc.	abc	40	Givat Shmuel	03-343471	03-343917
Technomatix	cd	70	Herzlia	09-594777	09-544402
Yael Software & Sys.	df	40	Givat Shumel	03-5323175	03-5323185

Universities and Government

Bar Ilan U.	bh	Ramat Gan	03-5318402	03-6771088
Ben Gurion U.	cdh	Beersheva	07-461111	07-281340
Hebrew U.	bh	Jerusalem	02-882111	02-664740
Jerusalem Col. Tech.	bcde	Jerusalem	02-751111	04-422075
Technion	aeh	Haifa	04-292111	04-221581
C. Appl. Computer Res.	bh	Haifa	04-293540	04-221581
Tel Aviv U.	bdi	Ramat Aviv	03-6408111	03-5414556
Weizmann Inst.	deh	Rehovot	08-342111	08-466966

a Computer hardware and peripherals ■ b Software engin., UNIX. C ■ c CAD/CAM ■ d Robotics, industrial automation
 ■ * Education, medicine, science ■ f Office mgt., publications ■ g Defence, security ■ h Theoretical research ■ i
 LAN, data communications

Also see page 41 for the following listings: BVR, Efrat Future Tech., Elbit, MBT, Rada, Rokar, and Tadiran.

H

Health Sciences

Israel has four world-class medical schools, 1200 ambulatory clinics and 12,000 practicing physicians -- all for a population of 5 million. Israel's research community is equally health conscious; over half of all Israeli articles in scientific journals are related to medicine. Israeli scientists were pioneers in using amniocentesis, culturing human white blood cells and producing commercial amounts of beta interferon. Every year brings more innovative products: an iron-binding malaria drug, a nasally-administered flu vaccine, a rapid diagnostic test for mycoplasmal pneumonia and "decoy" molecules that are 90% effective in preventing juvenile-onset diabetes in animal models. Many such advances proceed from their discovery in university laboratories, to development in local industry, to marketing abroad through joint ventures or under license.

Although Israel has made significant theoretical and scientific contributions to the biotechnology revolution, its investment in associated production engineering and bioindustry have lagged behind. Despite the publication of an influential MOSA-sponsored Katzir Committee Report in 1989, the government and private sectors still invest far less in biotechnology than in electronics or computer software. This may reflect the long development and payback time of many biotechnology products.

The dozen or so new biotechnology companies that have sprung up in the last decade have been highly innovative and successful, although most are still small (5-20 employees). Biotechnology sales reached \$60 million (5% of the world market) in 1991; but this is only a fraction of Israel's full theoretical potential, which is estimated at \$500 million by the year 2000.

Hybridoma Technology/Diagnostic Tests.

The body has special white blood cells (B cells) which produce defensive chemicals

(antibodies) in response to specific bacterial or viral attacks. Fusing B cells to rapidly-growing cancer cells creates hybrid cells (hybridomas) that produce copious quantities of highly-specific (monoclonal) antibodies. These can be used to make highly-sensitive diagnostic tests and vaccines. Israeli scientists and companies are in the forefront of these biotechnologies. BioMakor makes a wide variety of monoclonal antibodies (including antibodies to human leukocyte markers), immunodiagnostic products and bioactive peptides. Savyon Diagnostics make ELISA diagnostic kits that screen for sexually transmitted diseases, such as chlamydia and gonorrhea, and for blood antibodies against Epstein-Barr virus and Rous sarcoma virus. Organics' tests for AIDS, chlamydia, hepatitis and toxoplasma tests are used worldwide.

Genetic Engineering. Today's "genetic engineers" can move specific active DNA messages (sequences) from the cells of one species (even man) to another (bacteria) which is easier to grow. Using such techniques Israel's Interpharm Laboratories, a subsidiary of the Swiss firm Ares-Serono, produced the world's first commercial recombinant beta-interferon to treat genital herpes. Today its popular human fibroblast derived interferon (FRONE) is also being used against uterine and breast cancer. Interpharm has also genetically-engineered mammalian cell cultures (rather than bacteria) to produce chemically "authentic" cytokines, including interleukin-6. Bio-Technology General (BTG) was the first firm to produce recombinant bovine growth hormone. They now market an authentic human growth hormone. Several forms of BTG's superoxide dismutase (SOD) enzyme are being tested as a treatment for arthritis, colitis, bronchopulmonary dysplasia and inflammation. BTG also produces a hepatitis-B vaccine, a fibrin-binding peptide that helps visualize blood clots, and a high-

H Health Sciences

grade hyaluronic acid used in cataract operations.

Pharmaceuticals. Teva Pharmaceuticals, Israel's largest drug company (\$400 million in sales), produces everything from bakers yeast to veterinary vaccines. Its 120 man research staff have developed many innovative drugs. One drug, developed in conjunction with Weizmann Institute scientists, successfully halts and even reverses bone loss in victims of osteoporosis; another helped arrest multiple sclerosis in two U.S. clinical trials. Its ABIC subsidiary does much of its own fine-chemicals development and biological research, including research on cancer diagnosis and treatment. Life Science Research specializes in pharmaceutical safety testing; Isorad, in radiopharmaceuticals and medical diagnostics.

In the case of Israeli pharmaceutical manufacturers, size does not necessarily correlate with R&D activity. For example, several firms with 100-400 employees have less than 10 research staff. In general, the

biomedical research done in Israeli industry is still dwarfed by the sizable clinical and laboratory research programs in universities, hospitals and government research institutes. For example, Weizmann Institute drugs to treat multiple sclerosis (COP-1), stimulate immunity (THF), prevent hepatitis-B, and treat bronchopulmonary dysplasia (SOD) are all now undergoing clinical trials.

Biochemistry. Enzymes are natural catalysts that increase the speed, efficiency and hence profitability of biochemical reactions. Unikoor Industrial Biotechnology, a partnership between Koor Chemicals Ltd. and Hebrew University's YISSUM commercialization unit, have developed enzymatic catalysts for many important oxidation, esterification, polymerization, condensation and hydrolysis reactions.

Medical Devices. Elscint (\$238 million sales) is a world leader in state-of-the-art computerized tomography (CT), magnetic resonance imaging (MRI), nuclear medicine and ultrasound imaging systems. They have



H

Health Sciences

12 foreign subsidiaries and a 250-person research staff. Mennen Medical produces computer-based monitoring systems for critical and intensive care uses. Fidelity Medical's computerized real-time digital imaging systems for cardiac catheterization and GI labs allow on-line diagnosis and decision-making. SRD Shorashim's Cerebro-Trac computerized "brain wave" (EEG) monitor has been very successful in the European market. Spegas has developed a new system to monitor blood oxygenation.

Clinical Research. Israeli hospitals are variously sponsored by the Government, municipal authorities, international organizations or the Kupat Holim (the Histadrut's medical insurance plan). About 80% of the population uses Kupat Holim hospitals and clinics. Most large hospitals are also affiliated with one of Israel's four medical schools and participate in a wide variety of clinical and laboratory research projects. The table on the next page summarizes the detailed, 80 page description found in SRI (page 53). Updates can be obtained directly from the hospital or its university affiliate.

Government. The Israel Institute for Biological Research (IIBR) administers several national reference laboratories and a center for drug bioavailability testing (BEST). It also owns Life Sciences Research (toxicology testing), provides advanced technical services under contract and conducts extensive biotechnology pharmacological research, often under industrial sponsorship. R&D interests include novel drugs for CNS disorders (such as Alzheimer's disease), new drug delivery systems, genetically-engineered vaccines and immunomodulators for veterinary use, biologically-active peptides, and biofermentation scaleup.

MOSA helped set up a National Committee on Biotechnology and funds small research

projects in cardiology (03-5173668), cancer and biotechnology through FAIR (page 5), and through its Cooperative Program with Germany's BMFT.

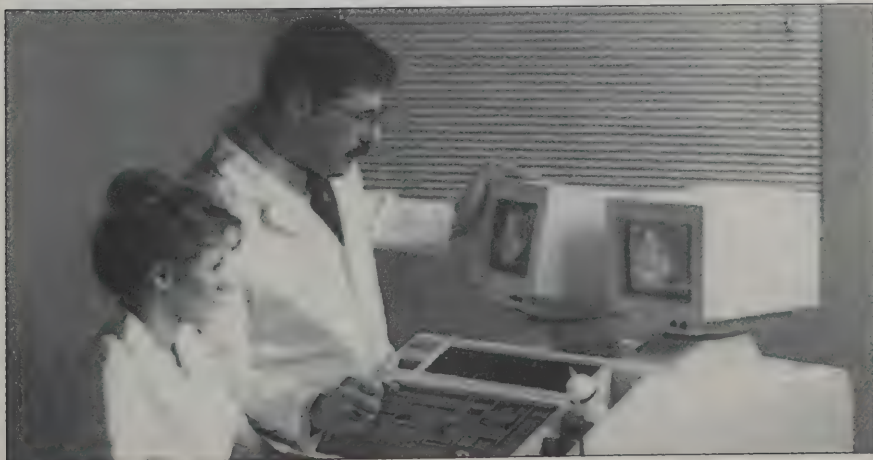
Societies/Networks. Israeli physicians belong to the Israeli Medical Association (IMA, 03-6969639), which also acts as an umbrella organization for 52 more specialized medical societies. The IMA's College of Continuing Education cooperates with medical associations abroad, especially in the USA. The IMA hosts a World Congress of Jewish Physicians in Israel every three years, and maintains close links with the World Health Organization (WHO) and the international medical community. Its many publications include the monthly *Israel Journal of Medical Sciences* (co-sponsored by MOSA), the fortnightly *Harefuah* (Hebrew) and a monthly *Mikhtav LeHaver* (Hebrew news bulletin). There is also an Israel Biochemical Society (FAX 08-466966) and an Israel Psychological Association (03-286446). Israel hosts the International Union on Immunological Sciences (08-483642).

H Health Sciences

Major Israeli Organizations in Medical & Biological Technology

Organization	Code	R&D	City	Phone	Fax
ABIC Pharmaceutical	b	43	Netanya	09-639777	09-354221
Bio-Technology General	bd	90	Rehovot	08-381209	08-409041
BioMakor	ac	20	Rehovot	08-408425	08-402142
Dexxon	b	12	Haifa	04-571252	04-575222
Elscint	e	250	Haifa	04-310390	04-550608
Fidelity Medical	e	38	Haifa	04-550225	04-550249
Franztech	e	13	Haifa	04-323262	04-320615
Interpharm Labs.	b-d	100	Nes Ziona	08-476786	08-465566
Isorad	bc	150	Yavne	08-434688	08-421446
Israel Inst. Biol. Res.	bd	300	Nes Ziona	08-381656	08-401404
Istec Ind. & Tech.	c	20	Ramat Gan	03-5279738	03-5279759
Laser Industries	e	60	Tel Aviv	03-493241	03-6483319
Life Science Research	b	60	Nes Ziona	08-401110	08-401443
Makor Chemicals	a	40	Jerusalem	02-893666	02-827474
Membrane Products	a	10	Nes Ziona	08-407557	08-407556
Mennen Medical	e	18	Rehovot	08-406751	08-406519
Microshev	e	12	Efrat	02-931922	02-931926
Organics	ce	15	Yavne	08-438752	08-438758
Pharmos	b	23	Rehovot	08-409679	08-409686
Savyon Diagnostics	c	12	Ashdod	08-562920	08-563258
SRD Shorashim	e	17	Misgav	04-886550	04-886375
Spegas	e	12	Jerusalem	02-828868	02-828873
Taro Pharm. Ind.	b	11	Haifa	04-723257	04-727165
Teva (excluding ABIC)	b	187	Petah Tikva	03-9267267	03-9234050

a Biochemistry, laboratory equip. ■ b Pharmaceuticals, hormones, vaccines ■ c Hybridoma tech., diagnostic kits
 ■ d Genetic Engineering ■ e Medical Devices



Major Israeli Organizations In

S	Organization	Anatomy/Physiology	Biochemistry	Biomedical Engineer	Cardiovascular Res.	Cell Biology/Histology	Computer Medicine	Embryology	Endocrinology	Epidemiology	Gastroenterology	Genetics	Geriatrics	Gynecology/Obstetr.	Hematology	Immunology	Microbiology	Molecular Biology
U	Hebrew U. + M.C.																	
U	Tel-Aviv U + M.C.																	
U	Technion + M.C.																	
U	Weizmann I.																	
U	Ben Gurion + M.C.																	
U	Bar Ilan U.																	
U	Jerusalem Col. Tech.																	
K	Beilinson M.C.																	
K	Carmel M.C.																	
K	Golda Meir M.C.																	
K	Jezrael Valley M.C.																	
K	Kaplan H.																	
K	Lowenstein H.																	
P	Hadassah M.C.																	
P	Shaare Zedek M.C.																	
M	TA.-Sourasky M.C.																	
M	Haifa M.C.																	
G	Asaf Harofeh M.C.																	
G	Barzilai M.C.																	
G	Chaim Sheba M.C.																	
G	Edith Wolfson M.C.																	
G	W.Galilee Reg. H.																	
G	Rambam M.C.																	
G	Min. Health Labs																	
G	Israel Inst. Biol. R.																	
I	ABIC Ltd.																	
I	Teva Pharm Ind.																	

* Institutions specializing in mental health (MH) include: U. Haifa (Wolfe Center), Talbia Psych. H. (Jer.), Shalvata MH Center (Hod HaSharon), Ezrath Nashim H. (Jer.) Nes Ziona MH Center (Nes Ziona), Pardessia Gov. H. (Netanya), Jerusalem MH Center

Medical and Health Research

	Nuclear Medicine	Occupational Health	Oncology	Ophthalmology	Orthopedics	Other Clinical Medicine	Pathology	Pediatrics	Pharmacy/Pharmacology	Psychiatry/Psychology*	Radiology/Imaging	Rehabilitation	Reproduction/Genetics	Surgery	Trauma Research	Virology	City	Telephone	A
																	Jerusalem	02-428111	HU
																	Tel Aviv	03-6408111	TA
																	Haifa	04-516111	HF
																	Rehovot	08-342111	—
																	Beersheva	07-461111	BGU
																	Ramat Gan	03-5318111	—
																	Jerusalem	02-751111	—
																	Petah Tikva	03-9268111	TA
																	Haifa	04-254082	HF
																	Petah Tikva	03-9221752	TA
																	Afula	06-524251	—
																	Rehovot	08-441211	HU
																	Raanana	09-446666	TA
																	Jerusalem	02-427427	HU
																	Jerusalem	02-555111	TA
																	Tel Aviv	03-697444	TA
																	Haifa	04-671671	HF
																	Zrifin	03-94804	TA
																	Ashkelon	07-45555	BG
																	Tel Hashomer	03-5310111	TA
																	Holon	03-5028111	TA
																	Nahariya	04-929711	—
																	Haifa	04-533111	HF
																	Jerusalem	02-381373	—
																	Nes Ziona	08-481411	—
																	Netanya	09-639777	—
																	Petah Tikva	03-9267267	—

A = Affiliation of teaching hospitals with corresponding medical schools.

H = Hospital, M.C = Medical Center, S = Sponsorship

J = University, K = Kupat Holim, P = Public, M = Municipal, G = Government, I = Industry

Agriculture

Agriculture, Israel's first major industry, still accounts for \$2 billion a year in sales, although exports (\$500 million, 80% to Western Europe) continue to decline. Citrus exports dropped to \$140 million in 1991; and the emphasis is increasingly on grapefruit (35% sales) and exotics, such as "easy-peelers." Although the Citrus Marketing Board no longer buys and markets the national crop; it still maintains an active program of research in pest control.

The outlook for several other areas is considerably brighter. Israel has now captured 40% of the European fruit/vegetable/melon market, and it is second only to Holland in European flower sales. Israeli agriculturists have pioneered agricultural biotechnology, trickle-drip irrigation (often microprocessor controlled), soil solarization and the sustained use of industrial waste water for agriculture. These advances have now been embodied in marketable products; and agrotechnology and agroequipment exports are expanding rapidly (\$845 million in 1991). Products range from genetically-engineered seeds and biopesticides to light-degradable plastics and computerized irrigation/fertilization systems.

Israeli agricultural biotechnologists have discovered potent antiviral substances in tobacco (one hundred-millionth of a gram has a measurable effect), have developed a test for potato leafroll virus (PLRV) that is so sensitive it can detect the PLRV on a single aphid, and have discovered a helpful trichoderma fungus that attacks pathogenic fungi while boosting potato growth 300%. Other scientists have developed modified-atmosphere storage methods that greatly reduce post-harvest losses of grains, vegetables and fruits.

Government-Sponsored Research. The Ministry of Agriculture's (MOA) Agricultural Research Organization (ARO) has extensive programs in all fields of

modern agricultural research. Its 1000 employees work in seven research institutes at the Volcani Center in Bet Dagan, and in eight ARO experimental stations throughout the country. ARO staff maintain close contact with both academia and farmers. The Kimron Veterinary Institute does research in poultry and dairy cattle diseases and in vaccine production.

Many of Israel's basic agricultural research projects are funded by BARD, the U.S.-Israel Binational Agricultural Research and Development Fund. Its \$10 million annual budget funds about 40 new U.S.-Israeli joint research projects each year. Each project receives about \$200,000 spread over three years.

Plant Sciences. Plant Biotechnology develops large scale, automated plant tissue culture (PTC) techniques for the rapid propagation of genetically identical plants (clones). Hazera breeds, tests and sells seeds of 300 commercial crop varieties, including their Daniela long-shelf-life tomato. Their biotechnology R&D focuses on developing new varieties. Over 80% of Hazera's vegetable seed production is now exported.

Pest Control. Ecogen produces biological pesticides and protectants, including *Pseudomonas* and *Telluria* (a previously unknown bacteria) formulations that control nematodes. They also produce a yeast (*Candida*) that protects stored fruit from rot, and a fungus (*Ampelomyces*) which kills powdery mildew. FRM, a YISSUM partnership with First Mississippi (USA), develops biopesticides and fungicides. The Citrus Marketing Board sponsors research on the biological control of the citrus white fly, woolly fly, rust mite and the Mediterranean fruitfly. Makhteshim Chemicals has invested \$21 million over the past five years in R&D on crop-protecting chemicals, biological fungicides, and bacteria that clean up oil spills

Agriculture

Animal Sciences. ABIC's Veterinary Division has developed a new third-generation quinolone drug that fights infection in poultry, cattle and fish, and an intermediate vaccine for gumboro disease in chickens. Bio-Technology General uses genetic engineering techniques to produce various new human and animal health-care products. Israel Oceanographic and Limnological Research Ltd. was founded by the NCRD, MOSA's predecessor. It is active in oceanography, mariculture and marine biology (page 46).

Agricultural Products/Byproducts. Migal-Galilee Technological Center is exploring alternative crops, new food products and industrial uses for agricultural wastes (biomass). Granot Technologies, a regional association of 43 kibbutzim, promotes improved agricultural productivity through innovative technology. One focus is the transformation of wastes into high value-added products.

Agricultural Engineering. Trickle drip systems conserve water, prevent soil salination, facilitate computerized control and permit the safe use of semitreated wastewater. Ein-tal and Netafim produce innovative trickle-drip irrigation systems

and components. Fertilizers & Chemicals Ltd. produces highly pure and soluble preparations suitable for use in trickle drip irrigation lines.

Universities. The Hebrew U. Faculty of Agriculture (Rehovot), is a full-scale Agriculture School with 120 faculty, 1600 students and seven associated research institutes (page 51). Their phytotron facility, unique in the Middle East, allows full control over day length, temperature and humidity throughout 16 growth rooms. Recent successes include soil solarization, poultry rebound diets, tomatoes that grow in salty water and onions with an 8-month shelf life. The Technion's Faculty of Agricultural Engineering and the Weizmann Institute's Plant Genetics Department are well-known in their specialties. Ben-Gurion U., Tel Aviv U., and Bar Ilan U. include agriculture-related research in their Life Science Departments.

Societies and Networks. Some agricultural researchers belong to the Israel Botanical Society (03-5459125), Entomological Society (03-9683520) or Zoological Society (04-293737). The Ministry of Agriculture (03-9683209) publishes many useful bulletins and other publications.

Major Israeli Organizations in Agriculture

Organization	Code	R&D	City	Phone	Fax
ABIC (Veterinary)	d	15	Netanya	09-639777	09-354221
Agan Chemical Manuf.	be	57	Ashdod	08-547257	08-547388
Bernad	c	25	Kib. Evron	04-855311	04-855333
Biological Industries	a	25	K. Bet Haemek	04-960595	04-859585
Bio-Technology General	d	90	Rehovot	08-381209	08-409041
Citrus Marketing Board	b	11	Bet Dagan	03-9683817	03-9683838
Dead Sea Bromine Group	e	75	Beersheva	07-297222	07-276076
Ecogen	ab	22	Jerusalem	02-733212	03-733265
Ein-Tal	c	10	Netanya	09-341166	09-618929
Fertilizers & Chemicals	e	25	Haifa	04-468111	04-451077
Gat Food Canners	f	10	Givat Hayim	06-368881	06-368805

Major Israeli Organizations in Agriculture

Organization	Code	R&D	City	Phone	Fax
Haifa Chemicals	e	33	Haifa	04-469737	04-469825
Hazera	a	40	Sde Gat	07-813228	07-814057
IMI Inst. Res. (TAMI)	e	250	Haifa	04-469411	04-450078
Israel Ocean.Limnol.Res.	d	140	Haifa	04-515202	04-511911
Koffolk	f	15	Tel Aviv	03-9219961	03-9230341
Koor Foods	f	20	Tel Aviv	03-5432222	03-6950440
Makhteshim Chemical	b	90	Beersheva	07-296661	07-280304
Migal-Galilee Tech.C.	cdf	80	K. Shmona	06-953511	06-944980
Netafim	c	10	K.Hatezerim	07-673111	07-420098
Osem Food Industries	f	25	Petah Tikva	03-9265265	03-9265216
Rotem-Amfert-Negev	e	95	Ashdod	08-511535	08-566219
Shafit Biol. Labs.	d	10	K. Shefayim	03-523401	09-523405
Tivall	f	10	Ashrat	04-858700	04-858798

Government

MOA/Agric.Res.Org.	a-f	760	Bet Dagan	03-9683111	03-9665327
Agricultural Engineering	c	87	Bet Dagan	03-9683303	03-9665327
Animal Science	d	75	Rehovot	08-470583	03-9665327
Field & Garden Crops	a	187	Bet Dagan	03-9683483	03-9665327
Horticulture	a	88	Bet Dagan	03-9683405	03-9669583
Plant Protection	b	120	Bet Dagan	03-9683457	03-9665327
Soils and Water	c	80	Bet Dagan	03-9683272	03-9665327
Technology & Storage	f	121	Bet Dagan	03-9683588	03-9604428
MOA/Fisheries Tech.Div.	d	11	Haifa	04-642345	03-9665327
MOA/Kimron Veterinary Inst	d	48	Bet Dagan	03-981111	03-9665327
MOA/Plant Protect.&Inspect	b	110	Bet Dagan	03-984891	03-9665327

Universities

Bar Ilan U.	a-c		Ramat Gan	03-5318402	03-6771088
Ben Gurion U./Inst.Appl.Res	a-c		Beersheva	07-461111	07-281340
Hebrew U./Faculty of Agric.	a-f	120	Rehovot	08-481186	08-462181
Agric.Res.Centers (7)	abcdf		Rehovot	08-481186	08-462181
Technion Agric.Res.C.(2)	c		Haifa	04-292111	04-221581
Tel Aviv U./Inst.(2)	a		Ramat Aviv	03-6408111	03-5414556
U. Haifa/Inst.Evolution	a		Haifa	04-240111	04-342104
Weizmann/Agric.Center (3)	ade		Rehovot	08-342111	08-466966

a Plant sciences, seed prod. ■ b Plant pathology, pest mgt. ■ c Agr. engineering, water mgt. ■ d Animal sci., drugs, vaccines ■ e Fertilizers, herbicides, hormones ■ f Food processing, feed, wastes

*E*lectro-Optics and Lasers

In 1991, the sales of Israel's rapidly-growing electro-optics sector exceeded \$900 million, more than 8 times their 1981 level. Israel is a world leader in fiber-optics, electro-optic inspection systems for printed circuit boards, thermal imaging night-vision systems, and electro-optics-based robotic manufacturing systems.

Many of Israel's newest electro-optic prototypes, often from university or Technology Incubator laboratories, were showcased at the December 1992 Israeli Business Opportunities in Lasers and Electro-Optics Exhibition (BOLEO), held in conjunction with the 8th Meeting on Optical Engineering in Israel. The Exhibition was organized by MATIMOP (page 10), with MIT and MOSA help. The electro-optics industry already employs over 5000 people and the prospects for continued growth seem bright.

Laser Design and Production. Israeli manufacturers, such as Optomix Technologies, concentrate on compact carbon-dioxide gas lasers for industrial applications such as cutting and welding. Gal-Or's new 10 watt carbon-dioxide laser is only 20 cm. (8 inches) long; and a 15 watt version is planned.

Fiber Optics. Fibronix specializes in high speed fiberoptic cables to connect printers, terminals and other peripherals via IBM-compatible controllers. Tel-Aviv U. scientists have developed hollow flexible infrared-transmitting fibers (1-5 mm. inner diameters) for medical applications. The fibers can carry 70 watts of IR radiation, and are cooled by a flow of cold gas through their center.

Infrared (IR) and UV Systems. Spectronix produces UV and IR flame, explosion and vapor detectors. CI Ltd. makes infrared remote-sensing and intrusion-detection systems for both civilian and military uses.

Industrial Applications. Industry needs fast image-processing systems for automated inspection, non-contact measuring and gauging. Robomatrix is active in all three. Their Modulaser System, winner of the 1992 Photonics Circle Award, offers 2- and 3-dimensional cutting. Elron has developed a computer-controlled laser system that cuts microchip (integrated circuit) designs quickly and economically.

Optrotech and Orbot Systems recently merged to form Orbotech. Their innovative technologies already control 80% of the world market for automated printed circuit board (PCR) inspection stations. They are now expanding into inspection systems for multichip modules and liquid-crystal displays (LCDs). Rafael has added sophisticated image-processing to a computer vision system to provide human face recognition for an experimental security system. Galai produces on-line particle monitoring, residual oil monitoring and machine vision systems for industry. Elop produces electro-optical sorting systems for industry and agriculture.

Medical and Scientific Applications. Israel pioneered laser surgery and fiber-optic catheterization technology. Laser Industries produces surgical lasers, scanners and intra-operative ultrasound systems. SRD Shorashim R&D has developed microprocessor-controlled instruments for physiological measurements, ECG analysis and eye-movement tracking. MBT has developed an automated electro-optical system to detect coliform bacteria in drinking water. Elop is working on an automated optical scanner to help identify likely cancers.

Universities. Most major Israeli universities have active optics and laser research programs; and the Hebrew University has a separate Laser-Matter Interaction Research Center. Tel Aviv University has an Electro-

Electro-Optics and Lasers

optics Research Center. The Technion, Ben-Gurion University (BGU) and the Jerusalem College of Technology (JCT) grant B.S. degrees in this area. Tel Aviv U. and BGU both grant M.S. and Ph.D. degrees. JCT has developed optical slip rings for Elscint and a commercial electro-optics system that measures the speed of (and distance between) cars.

Academic research interests are highly varied. They are best surveyed from university Annual Research Reports. Typical topics include: nonlinear optics, laser spectroscopy, chemical lasers, solar lasers, free electron lasers, optical information

processing, holography, multiphoton excitation, and IR and visible fiber optics. This extensive basic research effort provides a strong base for new high-tech applications.

Societies/Networks. Many scientists belong to ILEOS, the Israel Laser and Electro-optics Society (02-585680). MOSA maintains an electronic newsletter which provides on-line information on seminars, meetings, and other news in "Optics and Lasers" on BITNET (OPTICS-L@TAUNIVM). MOSA formed a National Committee on Electro-optics and Lasers (EO&L) in 1988, and has published comprehensive surveys on *EO&L in Israel* and *EO&L in Israeli Industry*.



Electro-Optics and Lasers

Major Israeli Organizations in Electro-Optics and Lasers

Organization	Code	R&D	City	Phone	Fax
C.I. Systems	dg	30	Migdal Haemek	06-543488	06-543570
Elop	ceg	300	Rehovot	08-386211	08-386826
Elbit	g	1080	Haifa	04-315315	04-520002
Elisra Electronic Sys.	g	(1000)	Bnei Brak	03-7545560	03-7545468
Elsint	cf	250	Haifa	04-310390	04-550608
Fibronics	c	80	Haifa	04-313313	04-550550
Galai Production	e	45	Migdal Haemek	06-543369	06-549781
Indigo	e	100	Rehovot	08-381818	08-408091
Int. Technol. Lasers	cg	17	Rishon Lezion	03-9616567	03-9616563
Irad Technologies	d	19	Jerusalem	02-828868	02-828873
i-Sight	e	16	Zichron Yaakov	04-397336	06-396307
Isorad	a-f	150	Yavne	08-434688	08-421446
KLA Instruments	ce	30	Migdal Haemek	06-542987	06-543136
Laser Industries	af	60	Tel Aviv	03-493241	03-6483319
Ophir Optronics	d	12	Jerusalem	02-818916	02-822338
Optomic Technologies	ac	25	Migdal Haemek	06-545440	06-545382
Orbotech Systems	c	180	Yavne	08-423533	08-438769
Orisol Orig. Sol.	ce	15	Rishon Lezion	03-9616526	03-9618984
Quick Technologies		18	Haifa	04-550011	04-551122
Robomatrix Tech.	e	20	Raanana	09-986976	09-986980
Rotem Industries	cef	15	Beersheva	07-567008	07-554502
Satec	c	15	Jerusalem	02-812324	02-812371
Scitex	e	307	Herzlia Bet	09-529222	09-559810
Semiconductor Devices	abdg	35	Haifa	04-906622	04-906626
Segnetron Israel	cef	10	K.Bialik	04-757962	04-755040
Spectronix	dg	12	Sderot	07-890645	07-890580
SRD Shorashim R&D	f	17	Misgav	04-886550	04-886375
Tadiran	cg	700	Holon	03-5577254	03-5564474
Visionic	g	30	Tel Aviv	03-495892	03-6471580

Universities and Government

Bar Ilan U.	abf		Ramat Gan	03-5318402	03-6771088
Ben Gurion U.	abf		Beersheva	07-461111	07-281340
Hebrew U.	b-f		Jerusalem	02-882111	02-664740
Jerusalem Coll.Tech.	a-g		Jerusalem	02-751111	02-422075
Technion	a-e		Haifa	04-292111	04-221581
Tel Aviv U.	a-f		Ramat Aviv	03-6408111	03-5414556
Weizmann Inst.	abce		Rehovot	08-342111	08-466966
Israel Atomic En. Comm.	a-f		Ramat Aviv	03-6462948	03-6462974

a Laser design and production ■ b Precision lenses, mirrors, materials ■ c Electro-optics and fiber optics ■ d UV, IR sources, detectors ■ e Industrial imaging, inspection, processing; office applications ■ f Spectrometry, medicine, basic research ■ g Defense, security applications.

C

hemicals, Machinery

Israel's first major industries exploited the chemical rich waters and deposits of the Dead Sea, a major national resource. Today fine chemicals, machinery, metals, ceramics, glass, textiles and plastics round out Israel's industrial base. Chemicals account for about a quarter of all Israeli exports, over \$3 billion a year in sales, and over 15,000 jobs. A dozen or so large companies have over 500 employees each.

Many industry leaders belong to the Israel Chemicals Ltd. Group (ICL, \$1.2 billion sales). ICL spends \$36 million a year on R&D, about half in its own 250-professional R&D Institute (TAMI). Formerly, a state-owned company, ICL is now traded freely on the Tel-Aviv Stock Exchange. It is in the middle of a lengthy \$1.5 billion expansion program; \$230 million was spent in 1993 alone.

Bulk Chemicals. The Dead Sea yields potash, magnesia, bromine, chlorine and other materials important for fertilizers, industrial feedstocks and intermediate chemicals. The international market for Israeli phosphate and bromine bulk chemicals continues to increase, and Israeli companies are expanding to meet demand. For example, ICL's Dead Sea Works (DSW, \$580 million sales) produces 2 million tons of potash annually. It is investing \$80 million to produce an additional 150,000 tons of potash fertilizer locally. DSW is also building an innovative \$350 million plant to recover magnesium from the residue of their potash extraction process, using new Israel-Russian technology and 15 new immigrant scientists. They hope to produce 25,000 tons (\$75 million) of the light metal by 1996.

The Dead Sea Bromine Group, also part of ICL, accounts for 30% of the world production of (and 60% of the international trade in) bromine products. It also is developing new bromine products such as advanced flame retardants, biocides,

pharmaceuticals and construction materials. Makhteshim Chemical Works makes everything from fungicides, herbicides and pesticides to plant growth regulators. Haifa Chemicals, the world's largest producer of potassium nitrate fertilizer, specializes in slow-release and soluble low-chlorine formulations. Rotem-Amfert- Negev has developed a new process to produce dicalcium phosphate from waste materials.

Asia is a new fast-growing market for Israeli agrochemicals. In 1992, 18% of ICL's sales were to China and India. The DSW is now planning to build a \$300 million potash plant in China.

Rubber, Plastics, Polymers, Ceramics.

Electrochemical Industries (Frutarom) produces polyvinyl chloride resins and cholor-alkalai products. Tambour Ltd. mostly does paint research; but also works at reclaiming metals and minerals from wastewater. One-third of Israel's 365 Kibbutz industries produce plastics and rubber products; another 18% work in metals. The Kibbutz Industries Association (03- 6955413) provides coordination and counseling. The Ministry of Industry and Trade (MIT) sponsors several Institutes that provide research and advice to the ceramic, fiber (polymer), plastics and metals industries.

Fine Chemicals, Cosmetics, Detergents.

Makor Chemicals makes fermentation products such as antibiotics and mycotoxins, enzymes, lectins, steroids, antibodies, growth factors and a wide variety of other biochemicals. Zohar-Dalia does R&D on the sulfonation, amylation and alkylation reactions required to synthesize chemical intermediates for cosmetics and detergents. Two-thirds of Fertilizer Chemical's \$100 million output is for local use; while over half of Koffolk's vitamins, feed additives and organic intermediates are exported.

C

hemicals, Machinery

Metals, Tools, Components. Carmel Forge's R&D includes hot-die forging, nickel and titanium alloys for aircraft engines, and seamless rings. Iscar produces innovative carbide and ceramic cutting tools, coatings and holders, and automated and robotic production systems. Isorad has developed an automated welding inspection system. Founded in 1991 to help Russian immigrant scientist entrepreneurs, Ontec has been developing new microgravity technologies for producing aluminum-lead (and other composite) bearings for vehicle engines.

Machinery. Electra's 1400 employees make air conditioners, and cooking and energy control devices. Robcad specializes in advanced robotic systems. Ricor designs and manufactures specialized metal systems that operate at ultra-low temperatures.

Universities. The Hebrew U. School of Applied Technology, the Technion Research and Development Foundation (TRDF) and the Ben-Gurion U. Institute for Applied Research are all active in industrial research, including problems of scaleup. The Technion and Ben-Gurion U. have extensive Chemical, Mechanical, Materials and Industrial Engineering faculties which cooperate with Israeli industry. Tel-Aviv U. has an Engineering Department, devoted largely to electronics and computers.

Societies and Networks. Most industrial engineers belong to the 15,000 member AEAI (page 43). There is also an Israel Chemical Society (66 Nordau Blvd., Tel Aviv). MOSA maintains electronic newsletters in Chemistry and Materials Science on BITNET (page 53).

Major Israeli Organizations in Chemical & Materials Engineering

Organization	Code	R&D	City	Phone	Fax
Agan Chemical Manuf.	d	50	Ashdod	08-547257	08-547388
Alliance Tire & Rubber	b	45	Hadera	06-328411	06-333308
Amiad Filtration	bf	15	K.Amiad	06-933581	06-935337
Carmel Forge	e	50	Tirat Hacarmel	04-539202	04-539205
Chemagis	d	21	Tel Aviv	03-5375121	03-5375090
Dead Sea Bromine Group	a-d	90	Beersheva	07-297222	07-276076
Dor Chemicals	d	(120)	Haifa	04-416952	04-415194
Electrochemical Ind.	abd	15	South Akko	04-851484	04-915725
Fertilizers & Chemicals	ad	25	Haifa	04-468111	04-451077
Gadot Petrochemicals	d	23	Ramat Gan	03-7510811	03-7518042
Haifa Chemicals	a	33	Haifa	04-469737	04-469825
IMI (TAMI) Inst. R&D	a-d	250	Haifa	04-469411	04-450078
Iscar	e	70	Tefen	04-970311	04-873741
Isorad	ef	150	Yavne	08-434688	08-421446
Israel Chem.(excl.TAMI)	a-d	390	Tel Aviv	03-5630222	03-5615391
Koffolk	d	15	Tel Aviv	03-9219961	03-9230341
Kulicke and Soffa	e	40	Haifa	04-550271	04-550785
Makhteshim Chemicals	bd	90	Beersheva	07-296661	07-280304
Makor Chemicals	d	40	Jerusalem	02-893666	02-827474
Membrane Products	bd	25	Rehovot	08-471557	08-471556
Negev Phosphates	a	40	Yeruham	07-564811	07-589044
Ontec	bce	25	Beersheva	07-280813	07-280811

C

hemicals, Machinery

Major Israeli Organizations in Chemical & Materials Engineering

Organization	Code	R&D	City	Phone	Fax
Ornat Turbines	f	35	Yavne	08-433777	08-439901
Rikor Cryogenic	f	17	K. Ein Harod	06-531703	06-531904
Rotem-Amfert-Negev	a	95	Ashdod	08-511535	08-566219
Siron Industries	f	25	Haifa	04-414371	04-414372
Tambour Paint & Chem.	abc	13	Akko	04-853611	04-853629
Urdan Industries	ef	8	Netanya	09-338074	09-610246
Zohar-Dalia	d	15	Kibbutz Dalia	04-897234	04-897200

Universities and Government

Bar Ilan U.			Ramat Gan	03-5318402	03-6771088
Ben Gurion U.			Beersheva	07-461111	07-281340
Hebrew U.			Jerusalem	02-882111	02-664740
C. for Indus. R&D			Jerusalem	02-882111	02-664740
Technion			Haifa	04-292111	04-221581
Technion R&D Found.			Haifa	04-292111	04-323056
Chemical Eng.Res.C.	bd	NA	Haifa	04-292936	04-323056
Chemical Testing Lab	a-d	NA	Haifa	04-292745	04-323056
Manufacturing Sys.C.	e	40	Haifa	04-292104	04-323056
Materials Eng.Res.C.	bce	NA	Haifa	04-294592	04-323056
Nat.Bldg.Res.Inst.C.	c		Haifa	04-292726	04-323056
Tel Aviv U.			Ramat Aviv	03-6408111	03-5414556
Weizmann Inst.	b		Rehovot	08-342111	08-466966
Isr. Ceramic & Silicate Inst.	c	12	Haifa	04-222107	04-325339
Israel Fiber Inst.	bd	36	Jerusalem	02-707377	02-707314
Isr.Inst. Metals	ef	42	Haifa	04-294474	04-235103
Isr.Inst. Plastics	b	9	Haifa	04-225174	04-320157
Isr.Standards Inst.	a-f	(600)	Ramat Aviv	03-6465154	03-419683

a Dead Sea & industrial chem. ■ b Rubber, plastics, polymers ■ c Ceramics, glass, bldg. mat. ■ d Fine chem., detergent, cosmetics ■ e Metals, dies, tools, components ■ f Machinery design, production

Aeronautics, Defense

As befits a small state surrounded by hostile neighbors, Israeli defense research remains a high national priority. It has also become a multi-billion dollar business. The field is dominated by three large industrial complexes, two of which -- Rafael and Israel Military Industries (IMI) -- are wholly owned by the Israel Defense Forces. The privately owned Israel Aircraft Industries (IAI) is Israel's second largest company.

The international downturn in defense purchases, budget tightening at home, and increased protectionism and competition abroad have cost many jobs. For example, IAI's workforce has dropped from 23,000 to 16,000 over the last six years. Their exports, however, are still over \$1 billion a year, thanks to innovative R&D and increased diversification into consumer-oriented products (now about 20% of sales). Although stringent security requirements may exclude immigrants from some sensitive defense facilities, they can usually be accommodated in less sensitive divisions. For example, IAI has already hired 70 Russian scientists to work on some 30 different R&D projects.

Military Hardware. Due to recent setbacks, IAI sales dropped to \$1.4 billion in 1993. About half of IAI's employees are engaged in R&D. The rest make everything from advanced fighter aircraft cockpit systems (Lavi technology) to reconnaissance drones to hydraulic systems. IAI's 6100-man Electronics Division includes MBT, Tamam, MLM and Elta subsidiaries. MBT develops and produces ship/air/ground borne missiles, laser-guided glide bombs and air defense targeting systems. Tamam specializes in military electro-optics, inertial systems and navigation equipment. MLM specializes in command/control/communications (C³) technology and large system integration programs. Elta develops multimode airborne radar and early warning systems, tactical ground radar, advanced electronics and

computer systems. IAI's 4000-man Aircraft Division developed the Kfir supersonic fighter, Astra and Galaxy business jets and Arava STOL aircraft. IAI's other two main divisions are Bedek Aviation and a Technology Division, which includes Ramta and SHL.

Rafael (\$420 million sales, \$150 million exports) develops missile systems (together with IAI/MBT), reactive tank armor, radar jammers, radar-decoy chaff-dispersion systems and training simulators. Rafael recently trimmed 1000 of its 6000 employees, but still has about 2250 R&D professionals. IMI's 38 factories and other subunits employ 13,000 workers, over 1000 of whom are R&D professionals. Research interests include tungsten-based heavy metal alloys and robotics systems.

Relations between the Israeli and U.S. defense establishments remain close, and mutual sales, cooperation and joint ventures are common. For example, Bet Shemesh Engines is jointly owned by Pratt & Whitney (40%) and the Israeli Government (60%). IAI has signed a \$60 million, 5-year agreement to retrofit 60 U.S. F-15 fighter aircraft in 1992; and Martin-Marietta (USA) will be marketing BVR Technologies' Ehud computerized aircraft guidance system.

Military Electronics. The "three E's" -- Elbit, Elisra, and Elop -- have 3600, 2300, 1100 employees and 875, 1300, 300 R&D staff respectively. Elbit is Israel's eighth largest company (\$600 million sales). Their DASH helmet for the F/A-18 Hornet displays flight and attack information directly on the pilot's helmet visor. The U.S. Army is buying 3000 pairs (\$80 million) of Elbit night vision goggles which automatically display flight data for helicopter pilots. Elisra, a Tadiran subsidiary, makes electronic warfare systems for planes and combat ships, intelligence systems, and image processing and communications systems. Tadiran itself

Aeronautics, Defense

recently agreed to sell \$50 million of computerized tactical communications equipment to the Australian army. Elop specializes in electro-optical fire control systems, helmet-mounted sights, naval turrets, thermal imagers, laser rangefinders, image processing and optical computing.

Rada Electronics' Commercial Automated Test System (CATS) reduces the time required to test cockpit electronics from 10 hours to less than one hour. Rokar International develops advanced countermeasure dispensing systems and reconnaissance control equipment. BVR produces Hotshot flight simulators and trainers, and pilot debriefing systems.

Software. Decision Systems Israel (DSI), is active in software engineering, C³, sonar systems, flight simulators and signal processing. The Government has given DSI about \$2 million to absorb 100 new immigrant scientists in the production of advanced commercial computer software (page 13). Participants receive 6 months of training in Hebrew, English, business and technology, and a guaranteed 3-year job (representing a \$12 million commitment by DSI). The newcomers are contributing to DSI's diversification into civilian markets (power-monitoring systems, a computerized tennis umpire, etc.). DSI has hired 20 more immigrant scientists on its own, and is thinking of starting its own technology incubator.

Space. The Israel Space Agency (ISA), affiliated with MOSA, coordinates national space R&D. Two OFEQ test satellites have already been launched. Future plans include the launch of a geosynchronous AMOS communications satellite and a low-orbit student-built TECHSAT "microsatellite." Israel's first major payload, a cluster of three ultraviolet telescopes (TAUVEX), is scheduled for a 1995 launch as part of a Russian SRG Observatory. The Geophysical

Satellite Observatory at Bar-Giora, one of the world's 30 laser tracking stations, is operated jointly with NASA (USA). IAI, Rafael, Tadiran, Elisra, ELOP, Optomics, Rotem and many universities participate in ISA programs.

Universities. Most Israeli universities support electronics, computers, materials, aeronautics and/or astronomy research of potential relevance to the defense industry. Hebrew U. and the Technion both have Aeronautical Engineering Departments and Aeronautical Research Centers. The Asher Space Research Institute integrates the Technion's space-related efforts.

Societies and Networks. Israeli engineers belong to the AEAI (page 43). The 400 member Israel Society of Aeronautics and Astronautics (P.O.B. 2956, Tel Aviv) publishes a quarterly *BIAF-Israel Aviation and Space Magazine*.

Aeronautics, Defense

Major Israeli Organization in Defense, Aeronautics & Security

Organization	Code	R&D	City	Phone	Fax
Advanced Technology	a-d	400	Tel Aviv	03-5483506	03-499990
Arco Elect. Control	ac	28	Rishon Letzion	03-5123030	03-9614675
Ashot Ashkelon Ind.	ab	25	Ashkelon	07-21511	07-728167
Astronautics C.A.	acd	90	Bnei Brak	03-5791555	03-5704404
Bet Shemesh Engines	a	20	Bet Shemesh	02-909841	02-911970
BVR Technologies	d	30	Givatayim	03-5715671	03-571668
Decision Sys. Israel	d	330	Givatayim	03-5313333	03-5313322
Efrat Future Tech.	d	200	Tel Aviv	03-5131313	03-5131309
Elbit	a-d	1080	Haifa	04-315315	04-520002
Electo Galil	e	20	Kiryat Shmona	06-951788	06-951432
Elisra Electronic Sys	a-d	1000	Bnei Brak	03-7545560	02-7545468
Elop Electro-Optics	a-d	300	Rehovot	08-386211	08-386826
Elta Electronics (IAI)	a-d	1200	Ashdod	08-572581	08-564568
Israel Aircraft Ind.	ab	8000+	Lod	03-9353111	03-9353131
IAI/Aircraft Division	ad	2000	Lod	03-9354136	03-9353453
IAI/Bedek Aviation Div.	a	3400	Lod	03-9353640	03-9354577
IAI/Electronics Div.	a-d	6100	Yehud	03-5360450	03-5363975
Israel Military Ind.	a-d	700	Ramat Hasharon	03-5485222	03-5485530
Magal Security Systems	e	15	Yehud	03-5364144	03-5366245
MBT Sys. & Space (IAI)	ad	720	Lod	03-5314001	03-5314130
MLM Systems Eng. (IAI)	d	1050	Be'er Yaakov	08-272511	08-272890
Microelectronics	d	11	Rishon Letzion	03-9612329	03-9612307
Motorola	de	2000	Tel Aviv	03-5658888	03-5624925
Nimda Co.	b	21	Givatayim	03-5712161	03-5715022
Rada Electronic Indus.	d	80	Herzlia Bet	09-542182	09-555176
Rafael	a-d	2000	Haifa	04-794777	04-794653
Reshef Technologies	d	22	Rishon Letzion	03-9612329	03-9612307
Rokar International	ad	25	Jerusalem	02-814959	02-866238
Soltam	b	45	Yokneam	04-896224	04-892045
Systemil	bde	28	Tel Aviv	03-496141	03-496508
Tadiran	d	700	Holon	03-5577254	03-5564474
Tamam Prec. Instr. (IAI)	d	300	Lod	03-5315017	03-5315140
Visonic	e	30	Tel Aviv	03-495892	03-6471580

Universities and Government

Hebrew U.	ad		Jerusalem	02-882111	02-664740
Jerusalem Col. Tech.	bde		Jerusalem	02-751111	02-422075
Technion	ad		Haifa	04-292111	04-221581
Aeronautical Res. C.	ad		Haifa	04-292308	04-221581
Asher Space Res. C.	ad		Haifa	04-293813	04-221581
Israel Space Agency	ad		Tel Aviv	03-6422297	03-6422298

a Airborne / space systems ■ b Ground-based systems ■ c Naval systems ■ d Military electronics, computers, navigation systems, simulators ■ e Security systems

In 1992 Israel's total energy consumption reached 8.3 million TOE (ton oil equivalents), or about 1.5 TOE per capita. This, in itself, is not excessive (Americans consume 5.4 TOE per capita); but Israel must import 96% of its energy -- some \$1.7 billion worth each year. The share of coal (24%, almost all used for electricity generation) continues to increase at the expense of oil, a more volatile resource. Israel's only major fossil fuel resource is 12 billion tons of low grade oil shales. Although recovering the shale's 500 million tons of oil is currently unfeasible, it can be burned directly, somewhat like coal. Long range plans call for 1 billion watts of shale-powered electricity. Solar energy and water power account for only 3% of Israel's energy needs, mostly through domestic rooftop water heaters.

Electricity. Israelis consume about 4.5 MW of electricity per person. The Israel Electric Corporation (IEC), which runs the national grid, provides over 5.8 billion watts peak power (double the 1986 load) from a comparatively few large units. These include a 1400 MW coal-burning plant in Hadera, and a 1100 MW one in Ashdod. The IEC's 250-person R&D Division concentrates on transmission and network planning; but there are also projects on superconducting magnetic energy storage (SMES), liquified natural gas (LNG), nuclear power, solar ponds, wind power, and environmental protection. Ganot Electronics has produced an automated Energy Management System, with help from the MIT/OCs.

Electric Fuel has developed a zinc-air battery which could revolutionize electric transportation. Demonstration and marketing are both well-along in Germany, whose Deutsche Bundespost hopes to electrify its 30,000 van fleet. Speeds of 70 mph, and ranges up to 200 miles, have been obtained with prototype power supplies

weighing only 30% more than conventional gasoline systems.

Coal. In the 1970's, 98% of Israel's electricity was generated from oil; now 55% is generated from 4 million tons (\$200 million) of imported coal. Current plans call for meeting 40% of all Israeli energy needs with coal by the year 2000. The National Coal Supply Corporation imports most of Israel's coal. The R. Bloch Coal Research Center at Ben Gurion U., funded by Germany's Minerva Foundation, does research on coal auto-oxidation, beneficiation, liquification and combustion systems.

Petroleum. Israel imports about \$1.3 billion of crude oil and petroleum products annually. The Institute for Petroleum Research and Geophysics uses advanced seismic and paleomagnetic techniques to aid oil exploration. Despite 40 years of searching, most finds to date have been small, although several new sites seem promising. The Israel National Oil Company recently hired six immigrant experts, under a special MOSA-sponsored program (page 13), to prospect for oil using advanced Russian techniques.

PAMA Alternative Energy Development Ltd., owned jointly by the IEC (50%), ICL (25%) and Oil Refineries (25%), is responsible for developing Israel's large oil shale resources. Their shale-burning demonstration plant at Mishor Rotem handles 50 tons of shale an hour and coproduces 5 MW of electricity and low-pressure steam for nearby Rotem Fertilizers. The success of their venture (already profitable) has led to plans for a 1000 MW shale-burning power installation. The first 75 MW unit should be operative by 1998. Ormat is now examining the feasibility of a 25 MW oil-shale power plant using conventional boilers.

Solar Energy. Israel is a world leader in

E nergy

solar energy technology. The Weizmann Institute's Solar Tower includes 64 computer-controlled heliostats (mirrors) which focus up to 3 MW of concentrated light onto targets housed in a 54 meter (175 ft.) high tower. Up to 5 experiments can be conducted simultaneously. One project involves splitting methane gas into hydrogen and carbon monoxide, which can be transported and recombined when and where needed. Another, in conjunction with Ormat and IEC, involves developing a 0.25 kw solar-powered gas turbine.

Paz Gas and Ben-Gurion U. (BGU) have developed an air conditioner that runs on the low temperature hot water (70-140 °C) which can be provided by solar heaters. Their demonstration unit now cools a visitor's center with a 100-seat auditorium. On a larger scale, the Dead Sea Works evaporation ponds use free solar energy (the equivalent of 7.5 million TOE worth!) to evaporate 150 million cubic meters of water a year. The ponds yield 2 million tons of potash annually.

Other Energy Sources. Israel has a useable wind potential of 600 MW. Israel's first 6 MW wind farm is now nearing completion in the Golan. The IEC is planning a 80 MW wind-turbine installation in the Golan. Ormat is a world expert in generating electricity from comparatively low-temperature heat sources, including industrial "waste heat." It's U.S. subsidiary is building a \$200 million 125 MW geothermal power plant in the Philippines. Solmat, which constructs "solar pond" power plants, is another Ormat subsidiary. Solmecs is developing ways to harness low-grade heat using electromagnetohydrodynamics (EMHD).

Government. The Ministry of Energy and Infrastructure (MEI) has primary responsibility for Israel's energy policy and research. About 45% of its R&D budget goes to oil shale research; the rest to solar energy

(21%), wind energy (8%) and other topics. The MEI recently helped establish a 20-man Joint Israeli-Russian Laboratory for Energy Research at Ben-Gurion U. It is also studying plans for a 800 MW pumped water facility at Parsa near the Dead Sea. The Israel Atomic Energy Commission's Negev and Nahal Soreq Nuclear Research Centers run 5-25 MW research power reactors.

Universities. Hebrew U. and the Weizmann I. both have broad-based Energy Research Centers. The Technion has an Energy Engineering Center; and Tel Aviv U. has a Center for Energy Studies. Ben Gurion U. has several projects on solar energy use and conservation, and an Institute for Solar Energy Technology. These and other efforts are coordinated by a National Coordinating Committee for Solar Energy Research.

Societies/Networks. Many energy engineers belong to the 20,000 member Association of Engineers and Architects in Israel (AEAI, 03-5240274). The AEAI serves as an umbrella organization for more specific professional societies in chemical, mechanical, electrical, industrial, hydraulic and civil engineering, etc. The AEAI publishes *Handassa VeAdrikhalut*, a monthly *Bulletin* (Hebrew) and *Technical Progress in Israel* (quarterly, English).

The Israel Institute of Petroleum and Energy (IIPE, 03-414271) has 33 corporate members who sponsor research and professional training. The Institute's Belfer Center for Energy Research supports contract research at universities. In-house research is limited. The Institute's School of Petroleum and Energy Sciences organizes seminars and courses, and helps run Tel-Aviv University's Gordon Center. The IIPE publishes both a Hebrew newsletter and a quarterly, *Israel Energy News* (English). MOSA sponsors an electronic newsletter on Energy (ENERGY-L@TAUNIVM.BITNET).

Major Israeli Organizations in Energy Research

Organization	Code	R&D	City	Phone	Fax
Bet Shemesh Engines	a	20	Bet Shemesh	02-909841	02-911970
Electric Fuel Ltd.	a	25	Jerusalem	02-322484	02-322252
Ganot Electronics	af	20	Petah Tikvah	09-335791	09-824478
Israel Electric Corp.	a	170	Haifa	04-355220	04-370690
Israel National Oil Co.	d	--	Tel Aviv	03-5142020	04-5142061
Lambda Electronics	a	22	Carmiel	04-985255	04-887487
Ormat Turbines	abd	40	Yavne	08-433777	08-439901
Rotem Industries	e	15	Beersheva	07-567008	07-554502
Satec	a	15	Jerusalem	02-812324	03-812371
Savin Electronics	a	12	Petah Tikvah	03-9211090	03-9241715
Solmat	b	13	Yokneam	04-896224	04-892045

Universities

Ben Gurion U.	a-d		Beersheva	07-461111	07-281340
J.B.Desert Res.C.	bf		Sde Boker	07-565010	07-555058
Bloch Coal.Res.C.			Beersheva	07-461111	07-281340
C.for Solar En.Tech.	b		Sde Boker	07-565010	07-555058
Jerusalem Coll.Tech.	a-b		Jerusalem	02-751111	02-422075
Hebrew U./Energy R.C.	a-d		Jerusalem	02-882111	02-664740
Technion/Energy Eng.C.	a-d		Haifa	04-293185	04-221581
Technion/C.Architect.R.	f		Haifa	04-294037	04-221581
Tel Aviv U./Gordon C.					
for Energy Studies	a-f		Tel Aviv	02-6408111	03-5414556
Weizmann/Energy R.C.	bd		Rehovot	08-342111	08-343111

Government

I.Petroleum Res.	d	20	Holon	03-805112	03-802925
Geophysics (MEI)					
Israel Atomic En.Comm.	e		Ramat Aviv	03-6462948	03-6462974
PAMA-En.Resources Dev.	d	30	Tel Aviv	03-481227	

a Electricity, meters, components ■ b Solar energy ■ c Coal ■ d Petroleum, gas ■ e Nuclear energy
 ■ f Conservation

E

nvironment

Industry. The Israeli public is becoming increasingly concerned about environmental problems. Although few industries specialize in environmental control products or services, most large industries have environmental officers or staffs to monitor, report and minimize environmental impacts.

Government. The Ministry of Environment recommends and enforces regulations to protect Israel's air, soil and water from serious pollution. Its publications include *The Biosphere* (Hebrew, monthly) and *Israel Environment Bulletin* (English, quarterly). The Ministry of Energy and Infrastructure's Earth Sciences Research Administration operates three major research institutes (see chart) and supports additional research through university grants and contracts. The Ministry of Transportation operates the Israel Meteorological Service. The Development Study Center advises many Ministries on urban and rural contracts.

The Institute for Petroleum Research and Geophysics (IPRG) surveys water resources and evaluates seismological risk. The IOLR studies the oceanography of the Eastern Mediterranean and its ecosystems, economically-viable mariculture, marine biotechnology and marine pollution. The Golan Research Institute and the Ramon Science Center do ecological research on Israel's northernmost and southernmost regions, respectively.

Universities and Industry. University departments and research institutes (page 51) have a wide number of programs related to the environment. Arid ecosystems and water resources management are particularly emphasized and Israeli desert agriculture and trickle-drip irrigation technologies are world famous. Hebrew U. scientists recently developed a filtration system, using dried water-ferns, that can recover over 90% of most metals from

industrial waste water. SATEC's staff of Soviet immigrant scientists have developed an environmentally safe method for recovering gold from discarded electronic circuit boards.

Societies/Networks. The Society for the Protection of Nature operates 25 field study centers and seven research centers devoted to the protection and appreciation of Israel's flora and fauna. It publishes nature magazines for children, youth and adults. One-quarter of its 450 staff do part-time research. There is also an Israel Geological Society (P.O.B. 1239, Jerusalem).

Major Israel Organizations in Earth Sciences and Environment

Organization	R&D	City	Phone	Fax
Government				
Ministry of Environment	170	Jerusalem	02-701596	02-251830
Earth Sciences Res. Admin. (MEI)	220	Jerusalem	02-520682	02-534828
Geological Survey of Israel	58	Jerusalem	02-208221	02-380688
I. Petroleum Res. & Geophysics (IPRG)	20	Holon	03-805112	03-802925
Israel Oceanographic Limnological Research Institute (IOLR)	140	Haifa	04-515202	04-511911
Israel Meteorological Service (MOT)	20	Bet Dagan	03-9682101	03-9682126
Development Study Center	18	Rehovot	08-474111	08-475884
Universities				
Ben Gurion U.- J.B. Desert Res.	100	Sde Boker	07-565010	07-555058
Hebrew U.-Center for Study & Management of the Environment		Jerusalem	02-882111	02-664740
Arid Ecosystem Research Center		Jerusalem	02-882111	02-664740
C. for Soil & Water Science		Jerusalem	02-882111	02-664740
Groundwater Research Center		Jerusalem	02-882111	02-664740
Technion- C.Res. on Environment		Haifa	04-292414	04-221581
Water Resources Engineering				
Center for Urban & Regional Studies		Haifa	04-294054	04-221581
Geodetic Research Station		Haifa	04-292111	04-221581
Weizmann I.-Dept.Environmental Sci.		Rehovot	08-342111	08-343111
Other				
Coastal & Marine Eng. Res. I.(CAMERI)	25	Haifa	04-292957	04-227661
Golan Research Institute	10	Katzrin	06-961330	06-961930
Jewish National Fund (Keren Kayemet)	—	Jerusalem	02-707411	02-228619
Ramon Science Center	10	M.Ramon	07-588764	07-555058
Society for the Protection of Nature	—	Tel Aviv	03-375063	03-377695
Satec	15	Jerusalem	02-812324	02-812371

Academic Research

Basic research represents the future of Israel's scientific enterprise. Thanks to a strong, active basic research infrastructure, Israel's scientific strength resembles that of countries many times its size. A few recent successes include the development of mice which can maintain functional human blood cells (including antibody-producing B cells), ductile solder-accepting high-temperature superconductors, drugs that prevent bone loss in osteoporosis, and the exclusion of a fourth family of low-mass neutrinos (with CERN).

Although Israel's universities are important participants in applied research (page 18-46), they are the predominant locus of Israeli basic research. Most advanced research is done in eight major universities and degree-granting institutes and one more narrowly focused college. In addition to the standard academic departments, most universities also have affiliated research centers and institutes devoted to specific, often interdisciplinary, topics such as energy, VLSI, arid-land ecosystems, etc.

Only about 15% of a university's basic research budget comes from its own resources -- tuitions, donations, etc. Government allocations and research contracts from industry provide some of the shortfall, but much of the rest comes from research grants obtained by the researchers themselves. Israeli investigators successfully compete for direct grants from foreign organizations (e.g. the U.S. National Institutes of Health). There are also several grants programs specifically designed for Israeli participation which support over 1500 research projects, totalling over \$65 million each year.

Each university's Research Authority Office (page 8) helps faculty members apply for and implement research grants. For example, Hebrew University's Research Authority processes some 800 research

proposals a year. Successful projects bring in about \$41 million of external R&D funds annually. About 75% of the Hebrew University's research portfolio is basic research; half of the remainder (applied research) is supported by industry through contracts and licensing agreements.

Investigators typically submit a detailed plan-of-work and budget for up to three years of support. These are evaluated by panels of external experts (peer review) for scientific merit and other program-specific criteria. Annual budgets typically vary from \$10,000 to \$80,000 a year. Since established institutions are usually preferred and Western-style grant writing is an "art", less experienced private individuals and new immigrants might do well to submit joint proposals with appropriate groups at local universities. An exception is MOSA's special grants program for new immigrants, administered by the Ministry's FAIR program (page 12).

All prospective applicants should first contact the grant agency's office directly to get copies of the program's procedures, guidelines, deadlines, priorities and any special submission forms. Competition is keen and success rates average 10-30%. Although time-consuming and often frustrating, applying for scarce grant funds is an unavoidable "fact of life" for most academic researchers.

Academic staff vary in rank and job security. A typical hierarchy might include: Full Professor (includes "tenure" = complete job security), Associate Professor, Senior Lecturer, Lecturer, Assistant. Except in exceptional cases, newcomers usually find their first positions in the lower, less secure levels.

The wide variety of basic research underway in Israeli universities -- as wide as the interest of their 7500 faculty members --

Academic Research

cannot be adequately described here. The Hebrew University alone has 2500 research projects in progress. In addition, each university has many unique features. For example, Bar-Ilan University combines a large number of special Jewish and social studies programs with a full range of research in the natural sciences and mathematics (but not engineering). Ben-Gurion University of the Negev began developing the Negev through its world-famous Arid Lands Research Institute. It now has a full-range of science and engineering departments plus a Medical School.

The Hebrew University of Jerusalem is Israel's oldest (1925). Spanning three Jerusalem campuses plus an Agricultural School in Rehovot, it includes almost every field of science, social science and humanities plus a Medical School, Pharmacy School, and Dental School. The Technion, also known as the Israel Institute of Technology, trains a large proportion of Israel's engineers and architects, and many of her scientists. Both basic and applied research are encouraged. Tel-Aviv University is one of Israel's largest. Its nine faculties and 90 departments cover virtually all branches of science, engineering, medicine, social sciences and humanities. The University of Haifa emphasizes the social sciences, and humanities, although there is also some research in psychology, aging and biological evolution.

Two other S&T institutions are smaller and more focused. The Weizmann Institute of Science is a prestigious center for research and graduate training (M.S., Ph.D. degrees) in the natural sciences and mathematics. Conversely, the Jerusalem College of Technology trains only undergraduates (B.S. degree) and limits its applied research to electronics, electro-optics, computers and related sciences. Students continue

traditional Jewish studies throughout; and fourth-year students must undertake and defend an independent industrial research project.

Other important educational institutions include the Open University (Ramat Aviv, 03-6460460) which offers 250 courses in 60 centers throughout the country to over 16,000 part-time and full-time students. It sponsors some research on educational materials and self-instruction technology. Its press publishes 450,000 bound books annually. The 5000 member Association for the Advancement of Science in Israel (02-5318433) publishes the *Proceedings of the Congress of Scientific Societies*. The Israel Academy of Sciences and Humanities (page 7) provides a national forum for senior scholars and coordinates Israeli participation in the International Council of Scientific Unions (ICSU).

The following tables provide a brief overview of basic research in Israeli institutions of higher learning. More detailed information can be obtained from:

- * *Scientific Research in Israel* (published by MOSA).
- * University catalogues (available from the university registrar).
- * Annual research reports (available from individually departments).
- * Other university publications.

University infrastructures and campuses can be rather large and complex. Newcomers might want to make a first exploratory visit with someone who knows the campus well. Telephone contacts are comparatively simple; the university operator (page 8) can usually connect you with the proper person or department.

Academic Research

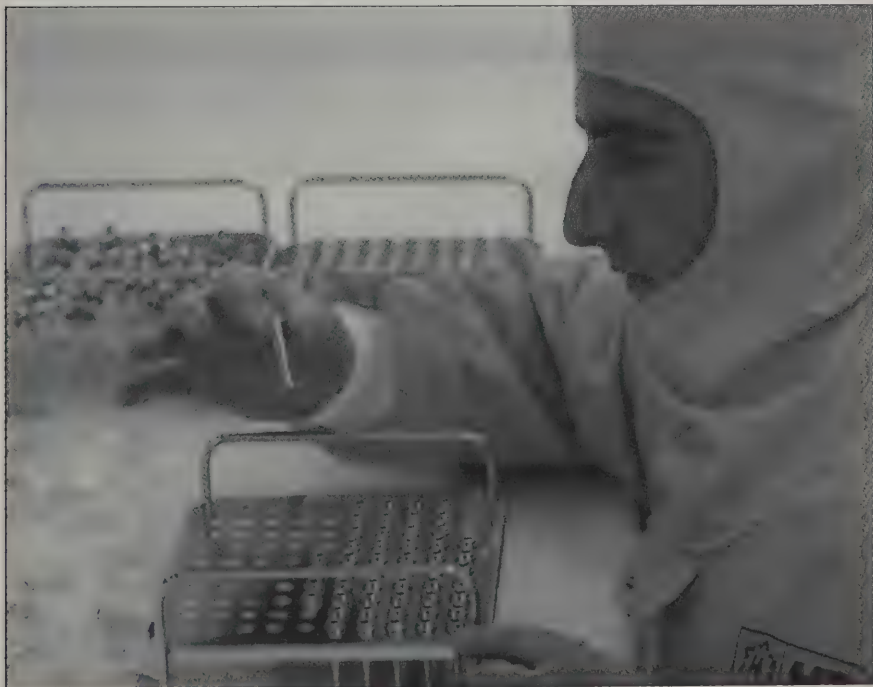
R&D Grants Programs Specific to Israel*

Program	Total Budget	Average Grant	New Grant	Active Grants	Phone	Special Requirements	Sponsor	Fax
FAIR	8	25,000	100	300	02-847057	Applied Goal	MOSA	02-825581
INSF	17	30,000	200 ⁺	475 ⁺	02-250103	Basic Research	IAS	02-245474
GIF	7	60,000	35	225	02-233814	German Partner	FRG**	02-233769
BARD	10	90,000	40	120	03-9683230	Agricultural Sci. U.S. Partner	USA**	03-9662506
BIRD	12	(Chapter 3)	40	60	03-6470710	U.S.-Israel Industries Only	USA**	03-498341
BSF	10	35,000	100	320	02-617314	Basic Research, U.S. Partner	USA**	02-633287
CDR	3	66,000	50	150	03-654338	Developing Country Partner	USA**	03-663449

* All numbers approximate. Budgets in millions of U.S. dollars per year.

** And the Israeli Government.

+ Plus 50 instrumentation grants.



Academic Research

Israeli Academic Research

Exact Sciences

	Bar-Ilan U.	Ben-Gurion U.	Hebrew U.	J.C.T.	Technion	Tel-Aviv U.	Weizmann I.
Computer Sciences	✓	✓	✓	✓	✓	✓	✓
Mathematics	✓	✓	✓	✓	✓	✓	✓
Physics	✓	✓	✓	✓	✓	✓	✓
Biophysics	✓	✓	✓	✓	✓	✓	✓
Nuclear Sci./Eng.		✓	✓			✓	✓
Physical Chemistry	✓	✓	✓		✓	✓	✓
Inorganic Chemistry	✓	✓	✓		✓	✓	✓
Organic Chemistry	✓	✓	✓		✓	✓	✓
Biochemistry	✓	✓	✓		✓	✓	✓
Geosciences		✓	✓		✓		✓
Energy		✓	✓	✓	✓	✓	✓

Life Sciences

Animal Sciences	✓	✓	✓		✓	✓	✓
Cell Sciences	✓	✓	✓		✓	✓	✓
Clinical Medicine		✓	✓		✓	✓	✓
Ecology/Environ.	✓	✓	✓		✓	✓	✓
Health Sciences	✓	✓	✓	✓	✓	✓	✓
Molec. Genetics	✓	✓	✓		✓	✓	✓
Neuroscience	✓	✓	✓		✓	✓	✓
Physiology	✓	✓	✓		✓	✓	✓
Plant Sciences	✓	✓	✓		✓	✓	✓
Other Biology	✓	✓	✓		✓	✓	✓

Engineering

Aerospace					✓	✓	
Chemical Eng.		✓	✓		✓		
Electrical Eng.		✓	✓	✓	✓	✓	✓
Indust. Eng.		✓	✓		✓	✓	
Material Sciences		✓	✓	✓	✓	✓	✓
Mechanical Eng.		✓	✓		✓	✓	
Other Engineering				✓	✓	✓	

Academic Research

Research Centers/Institutes in Science and Engineering

Bar-Ilan University

Cancer, AIDS and Immunology Res. Inst.
Gelbart Res. Inst. in Mathematical Sc.
Inst. Information Retrieval and
Computational Linguistics
Lusinchi C. Applied Res. in Life Sciences.

Ben-Gurion University

Blaustein Institute for Desert Research
Center for Health Sciences
Humphrey Institute for Social Ecology
Institute for Applied Research

Hebrew University

Applied Genetics Experiment Farm
Arid Ecosystems Research Center
C. Normal & Leukemic Blood Cells
C. Rationality and Decision Theory
Casali Inst. of Applied Chemistry
Center for the Study of Aging
C. Agricultural Economic Res.
Center for Medical Education
C. Study & Mgt. of the Environment
Chanock Center for Virology
Diabetes Research Center
Energy Research Center
Farkas C. Light-Induced Processes
Frank Laser-Matter Interaction R.C.
Haber Center for Molecular Dynamics
Heart Disease Prevention Res. Center
Hebrew Univ. Science Teaching Center
Humphrey C. Exper. Med. & Cancer
Inst. for Advanced Studies
Interuniversity Red Sea Res. Center
Katz C. Cell Biophysics
Kuhn C. Studies in Visual Transduction
Landau C. Res. in Mathematical Analysis
Lautenberg C. Gen. & Tumor Immunol.
Leibniz C. Res. in Computer Science
Loewi C. Cellular & Molecular
Neurobiology
National Inst. for Psychobiology

Pain Research Center
Pilot Plant (Chemical Engineering)
Seagram C. Soil and Water Sciences
Shilo C. Marine Biogeochemistry
Szold Institute for Applied Science
Trauma Research Center
Triwaks Bee Research Center
Warburg C. Biotechnology in Agriculture

Jerusalem College of Technology

C. Driver Research & Injury Prevention
C. Tech. for the Handicapped
Kukin C. Image Processing and Analysis
in Medicine.
Nebenzahl I. Human Safety
Sugarc Solar Energy & Thin Films Lab.

Technion - Israel Institute of Technology

Asher Space Research Institute
C. Environ. & Water Resources Eng.
Electro-Optics Research Center
Energy Engineering Center
Microelectronics Research Center
Mineral Engineering Research Center
National Building Research Institute
Rappaport Inst. Res. Medical Sciences
R. C. Very Large Scale Integration (VLSI)
Silver Inst. of Biomedical Engineering
Solid State Institute
Transportation Research Institute
Ullman C. Manufacturing System &
Robotics

Technion R&D Foundation

Coastal & Marine Eng. Res. Inst.*
Fife Building Materials Testing Lab.
Geodetic Research Station
Hydraulic Testing Laboratory
Ilieff Chemical Testing Laboratory
Israel Institute of Metals
Soil and Road Testing Laboratory

Tel-Aviv University

Abramson C. Medical Physics
Botanic Gardens
C. Technological Analysis & Forecasting

Academic Research

Canadian C. Ecological Zoology
 Cancer Biology Research Center
 Center for Nuclear Res. (Nahal Soreq)
 Dead Sea Research Center
 Eskenasy Inst. for Cancer Research
 Eskenasy Institute of Computer Sciences
 Eskenasy Center for Superconductivity
 Glasberg Tower for Medical Research
 Goldschleger Eye Inst. (SMC)
 Gordon Center for Energy Studies
 Inst. Cereal Crops Improvement
 Inst. Cancer Research
 Inst. Nature Conservation Research
 Inst. Petroleum Research & Geophysics
 Institute for Petroleum and Energy
 Israel Inst. Biological Research*
 Kranzberg Inst. for Electronic Devices
 Nadler Inst. Archaeology
 Neufeld Cardiac Res. Inst.
 Rogoff-Wellcome Med. Res. Inst.
 Sackler Inst. Molecular Medicine
 Sackler Inst. of Advanced Studies
 Sackler Scientific Computation Center
 Sackler Inst. Solid State Physics
 Sackler Inst. Theoretical Physics
 Schreiber Inst. Mathematical Sciences
 Wise Observatory

Weizmann Institute

Braun C. Submicron Research
 Center for Neurosciences
 Cohn C. Biomembrane Research
 Dobrin Center for Nutrition
 Einstein C. Theoretical Physics
 Energy Research Center
 Forchheimer C. Molecular Genetics
 Gauss Minerva C. Sci. Computations
 Grodetsky C. R. Higher Brain Function
 Haber C. Physical Chemistry
 Kimmelman C. Biomolecular Structure
 Koch Minerva C. Autoimmune Disease
 Levine C. Applied Research
 Lubin C. Plant Biotechnology
 MacArthur C. Molec. Biol. Trop. Diseases
 Mazer C. Structural Biology
 Meller C. Biology of Aging

Sussman C. Environmental Sciences
 Willstätter C. Res. Photosynthesis

Ctr. = Center (for, of)

Inst. = Institute (for, of)

Res. = Research

* = Independent affiliate

This list excludes: (1) Social Sciences and Humanities research and (2) institutes which simply parallel or replace standard university departments (e.g. Chemistry Department = Chemistry Research Center). Most centers are named by or for major donors. In the interest of space, some titles have been shortened.

F

urther Information

For further information on this or other activities of the Israel Ministry of Science and the Arts (MOSA) please contact the:

Ministry of Science and the Arts

P.O. Box 18195

Jerusalem 91181

Telephone: 02-847096

FAX: 02-825581

TELEX: 26188 RECO IL

E-Mail: DANNY@ILNCRD.BITNET.

Other useful references include the comprehensive 550 page directory *Scientific Research in Israel* (SRI), available from MOSA or local bookstores. *Duns Guide Israel* (03-5103355) and *Kompass Israel* (03-5619374). Directories of Israeli high-tech industries in specific fields are published periodically by the Israel Export Institute (03-5142830).

Recent happenings affecting Israeli science, technology and high-tech industry can be found in the *Jerusalem Post* (daily), *Jerusalem Report* (biweekly) and *Link*

Magazine (monthly). Annual research reports, annual reports and department descriptions are available free-of charge from all Israeli universities, and many Israeli companies. MOSA's own 100 page *Publications Catalogue* lists over 350 entries. Many are available free-of-charge.

MOSA also maintains a variety of electronic newsletters for scientists with access to BITNET (accessible from any university). These include:

Chemistry (CHEMIC-L)
Computer Science (COMP-SCI)
Energy (ENERGY)
General R&D (ITEX-L)
Materials Science (MACTECH)
Optical Computing (OPTICOMP)
Optics (OPTICS-L)
Physics (PHYSIC-L)
Space Sciences (SPACE-IL)
Superconductivity (SUP-COND)

all at the address: @TAUNIVM.
For a complete updated list contact MOSA or JO@ILNCRD.

Notes

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